

International

Telemedicine/

Disaster Medicine

Conference

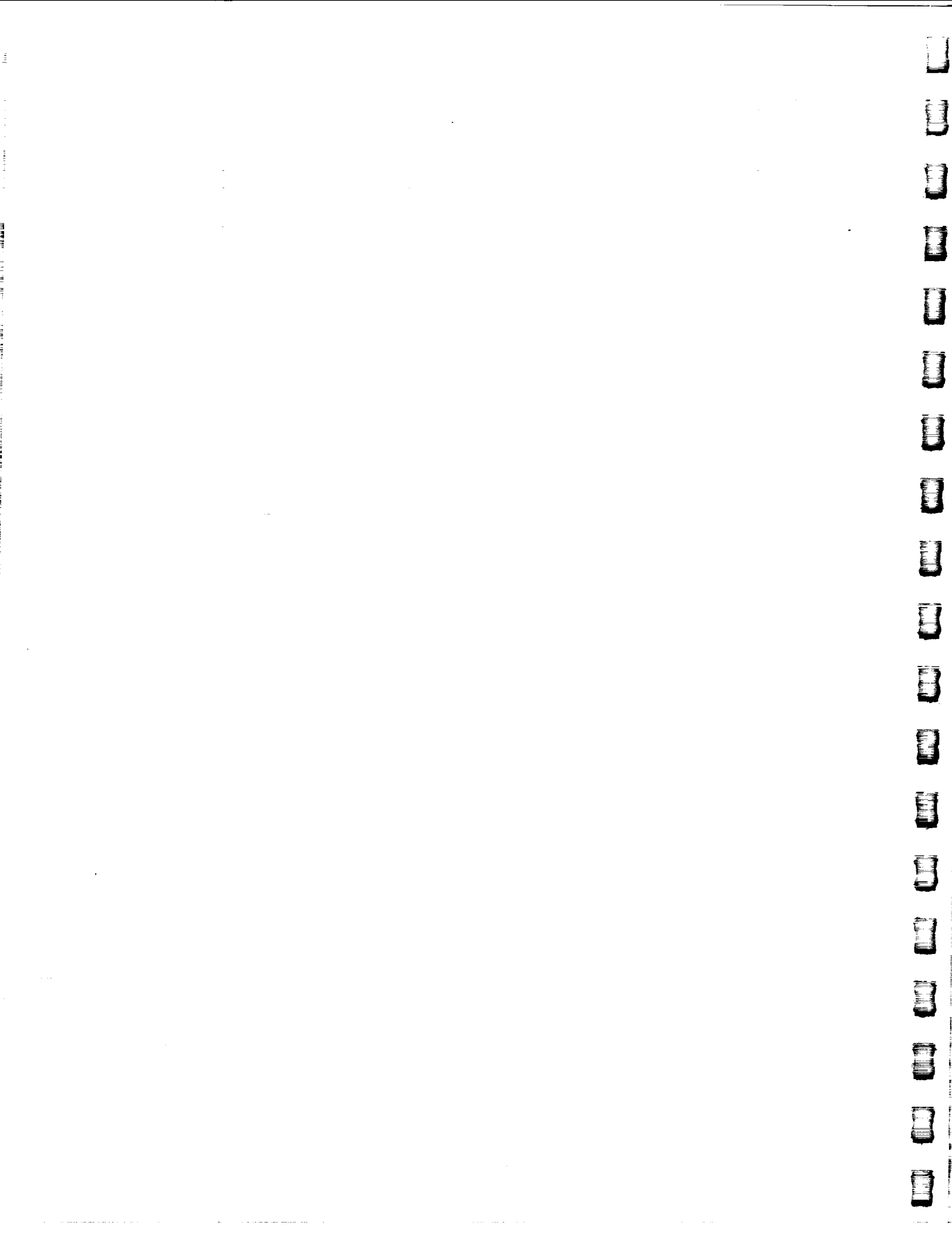
Presentations

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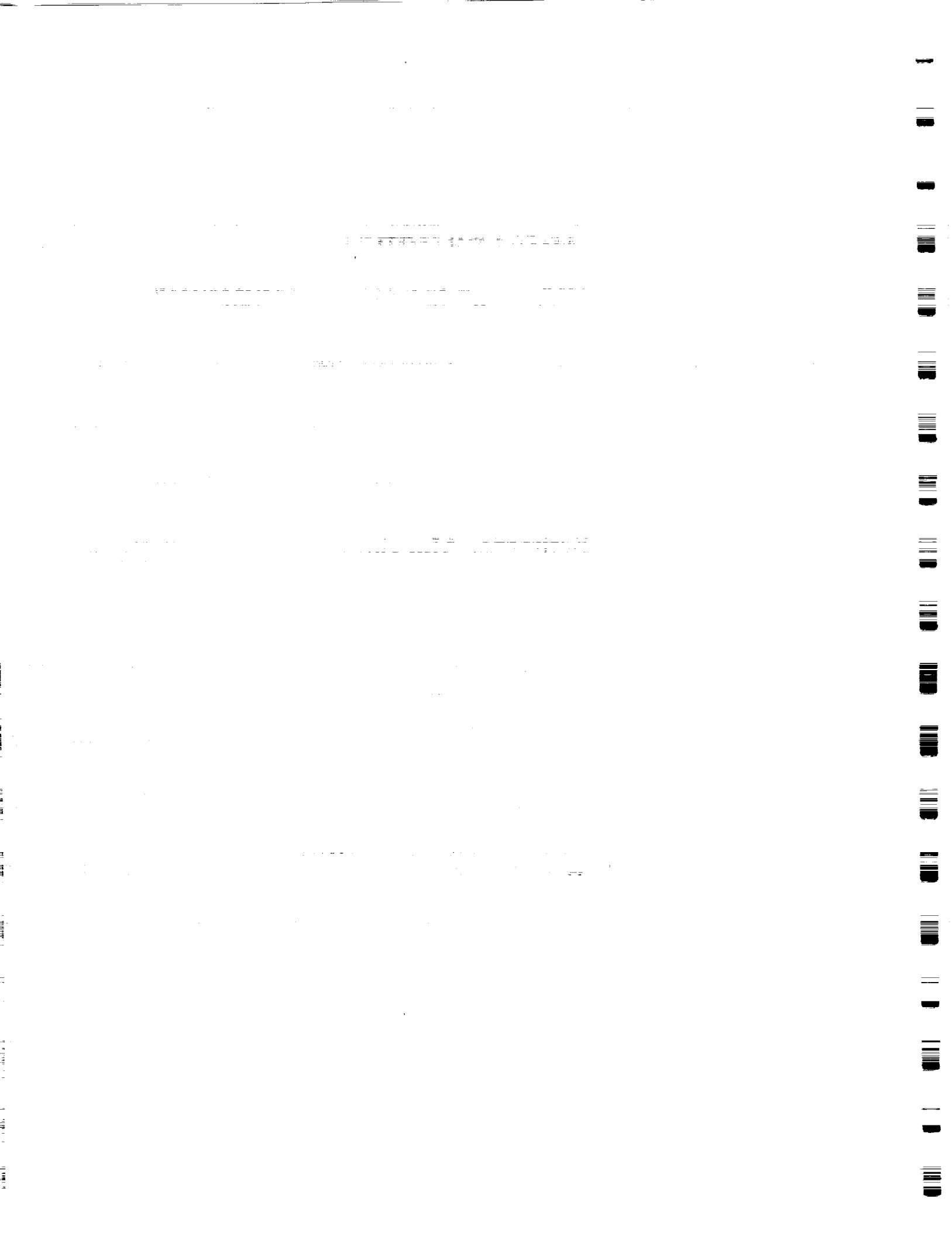
**International
Telemedicine / Disaster Medicine
Conference**

Papers and Presentations

**December 9-11, 1991
Bethesda, Maryland**

NP-207

**Donald F. Stewart, M.D.
Program Chairman**



Preface

The first International Telemedicine/Disaster Medicine Conference was held on December 9-11, 1991, at the Uniformed Services University of the Health Sciences (USUHS) in Bethesda, Maryland. It was jointly sponsored, organized, planned, and conducted by the USUHS, the National Aeronautics and Space Administration, and the American Institute of Aeronautics and Astronautics. The overall purpose was to convene an international, multidisciplinary gathering of experts to discuss the emerging field of telemedicine and assess its future directions; principally the application of space technology to disaster response and management, but also to clinical medicine, remote health care, public health, and other needs.

The papers contained herein were written by many of the foremost members of the biomedical and space science communities who addressed the Conference. The papers reflect the diversity of disciplines, ideas, visions, and individuals associated with telemedicine, which was defined by Dr. Harry C. Holloway for the purposes of the Conference as "medicine practiced at a distance." This collection is intended to acquaint the reader with recent landmark efforts in telemedicine as applied to disaster management and remote health care, the technical requirements of telemedicine systems, the application of telemedicine and "telehealth" in the U.S. space program, and the social and humanitarian dimensions of this exciting new area of medicine.

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Acknowledgements

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**Preparation of this document was made possible by the efforts of the individuals below:
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Table of Contents

Conference Organization
Session Chairs
Conference Goals
Introduction

Papers and Presentations:

Welcoming Address / Introduction to the Conference

Arnauld E. Nicogossian, M.D., and Harry C. Holloway, M.D.

Remarks Delivered at the International Telemedicine/Disaster Medicine Conference

Vice Adm. Richard H. Truly

Medical Informatics and Telemedicine: A Vision

Terry P. Clemmer, M.D.

The Canadian Experience: Using Telemedicine for the Support of Medical Care at Remote Sites

Max House, C.M., M.D., F.R.C.P.C.

Telemedicine and International Disaster Response: Medical Consultation to Armenia and Russia Via a Telemedicine Spacebridge

Bruce A. Houtchens, M.D., et al.

Use of Telescience for Biomedical Research During Space Flight

Carolyn L. Huntoon, Ph.D., Howard J. Schneider, Ph.D., Gayle M. Karamanos

Global Considerations for Implementation of Telemedicine

M. F. Lechat, M.D.

Tropical Medicine: Telecommunications and Technology Transfer

Llewellyn J. Legters, M.D., M.P.H.

Applications of the INTELSAT System to Remote Health Care

Andrea Maleter

Clinical Aspects of Telemedicine

Ronald C. Merrell, M.D., F.A.C.S.

New Technology Applied to Telemedicine

Edward F. Miller

Linking Medical Records to an Expert System

Frank Naeymi-Rad, Ph.D., and David Trace, M.D.

Commercial Applications of Telemedicine

Thomas A. Natiello, Ph.D.

Space Technology in Remote Health Care

Sam L. Pool, M.D.

Table of Contents

(Continued)

The Use of Communication Technology in Medicine
Howard P. Reis

The National Disaster Medical System
Thomas P. Reutershan

Satellite, Environmental and Medical Information Applied to Epidemiological Monitoring
Donald R. Roberts, Ph.D., and Llewellyn J. Legters, M.D., M.P.H.

A Telemedicine Health Care Delivery System
Jay H. Sanders, M.D.

Communications Infrastructure Requirements for Telemedicine/Telehealth in the Context of Planning for and Responding to Natural Disasters: Considering the Need for Shared Regional Networks
John Carver Scott

International Disaster Research
Martin Elliott Silverstein, M.D., F.A.C.S.

Medical Care Delivery in the U.S. Space Program
Donald F. Stewart, M.D.

Use of Satellite Telecommunications for Telemedicine
Gennady Tamkovich, Ph.D.

Use of Low Orbital Satellite Communications Systems for Humanitarian Programs
Vladimir N. Vlasov and Vladimir Gorkovoy

- Appendix A: Final Project Report—U.S./U.S.S.R. Telemedicine Consultation Spacebridge to Armenia and Ufa
- Appendix B: HR 5238—The Revitalization of Health and Education in Rural America Act of 1992
- Appendix C: Participant List

Conference Organization

GENERAL CHAIRMEN

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National Aeronautics and Space Administration

Harry C. Holloway, M.D.
Deputy Dean
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Uniformed Services University of the Health Sciences

Alexander Kiselev, M.D.
Director
NPO Soyuzmedinform

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Assistant Commandant Navy Element
Uniformed Services University of the
Health Sciences

1. The first part of the report is a general introduction to the project.

2. The second part is a detailed description of the methodology used.

3. The third part is a discussion of the results of the study.

4. The fourth part is a conclusion and a list of references.

5. The fifth part is a list of appendices.

6. The sixth part is a list of figures and tables.

7. The seventh part is a list of abbreviations and acronyms.

8. The eighth part is a list of symbols.

9. The ninth part is a list of footnotes.

10. The tenth part is a list of references.

11. The eleventh part is a list of appendices.

12. The twelfth part is a list of figures and tables.

13. The thirteenth part is a list of abbreviations and acronyms.

14. The fourteenth part is a list of symbols.

15. The fifteenth part is a list of footnotes.

Session Chairs

OPENING SESSION

Conference General Co-Chairmen

Arnauld E. Nicogossian, M.D.
Director, Life Sciences Division
Office of Space Science and Applications
National Aeronautics and Space Administration

Harry C. Holloway, M.D.
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F. Edward Hébert School of Medicine
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SESSION II: MEDICAL PROVISIONS WITHIN DISASTER MEDICINE

Yuri Vorobiev
Vice Chairman on the Commission on Disaster Management
U.S.S.R.

SESSION III: SPACE TECHNOLOGY FOR DISASTER MEDICINE

Ray J. Arnold
Deputy Assistant Administrator for Commercial Programs
National Aeronautics and Space Administration

Lawrence P. Chambers
Manager, Life Sciences Space Station and Soviet Flight Programs
Life Sciences Division
Office of Space Science and Applications
National Aeronautics and Space Administration

SESSION IV: CASE STUDY—LESSONS LEARNED FROM THE ARMENIAN SPACEBRIDGE

Emil Gabrielian, M.D.
Professor, Republic Diagnostic
Former Minister of Health, Republic of Armenia

Harry C. Holloway, M.D.
Deputy Dean
F. Edward Hébert School of Medicine
Uniformed Services University of the Health Sciences

Session Chairs (Continued)

SESSION V: REMOTE HEALTH CARE DELIVERY

Arnauld E. Nicogossian, M.D.
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Office of Space Science and Applications
National Aeronautics and Space Administration

Samuel L. Pool, M.D.
Chief, Medical Sciences Division
Lyndon B. Johnson Space Center
National Aeronautics and Space Administration

SESSION VI: THE USE OF TELEMEDICINE AND INFORMATICS IN FUTURE INTERNATIONAL DISASTERS

Donald A. Henderson
Associate Director for Life Sciences
Office of Science and Technology Policy
Executive Office of the President

Viatcheslav Kalinin, M.D.
Minister of Health
Republic of Russia

SESSION VII: THE ROLE OF CLINICAL SUB-SPECIALITIES WITHIN TELEMEDICINE

Haik Nikogossian, M.D.
Director
NPO Diagnostika
Republic of Armenia

James A. Zimble, M.D.
President
Uniformed Services University of the Health Sciences

SESSION VIII: REGIONAL AND ORGANIZATIONAL CONSIDERATIONS

Samuel W. Keller
Associate Deputy Administrator
National Aeronautics and Space Administration

P. Diane Rausch
Assistant to Associate Deputy Administrator
National Aeronautics and Space Administration

Conference Goals

Participants at the International Telemedicine/Disaster Medicine Conference considered the following questions:

1. What is (or are) the definition(s) of telemedicine?
2. Under what conditions can modern communications and information technologies contribute to the improvement in disease prevention or efficacy of medical practice? Specific considerations include
 - a. types of applications (e.g., disaster, care to remote areas or informatic applications—medical imaging, or applications to laboratory or electronic data transfer)
 - b. factors related to scales (e.g., local, national, international)
 - c. economic impacts (e.g., through improved efficacy or lower overall cost).
3. Are the potential telemedical applications and related informatics requirements being addressed by the medical academic community so that training programs exist to communicate the applications of telemedicine? Is information about telemedicine well represented in medical school curricula and the continuing medical education of practicing physicians? If not, what should be done to change this?
4. How should telemedicine be used in medical education—local (e.g., in district, state, or urban setting), national, or internationally? Who can serve as a proponent for such applications?
5. What institutional entities should be involved in the development of the practice of telemedicine? What national and international institutions? What should the private and governmental contribution to telemedical activities be?
6. What institutional entities should be responsible for developing and evaluating protocols for the practice of telemedicine?
7. What can be done to document the effectiveness of telemedical applications and specific protocols for improving medical efficacy, cost saving for specific applications, and applications to disaster relief?
8. Does telemedicine provide a critical resource to disaster relief efforts? What should be the role of telemedicine in the various of disaster relief?

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Introduction

The value of telecommunications technologies in the delivery of health care has been amply demonstrated over the last 20 years, as the papers gathered in this publication show. A major step forward was the large-scale application of space technology to the treatment of disaster casualties in 1988 and 1989, with the U.S./U.S.S.R. Telemedicine Spacebridge. The first International Telemedicine/Disaster Medicine Conference, conducted in December 1991, was planned as a follow-up activity to the Spacebridge.

The objective of the conference was to provide a forum for an international body of experts to discuss the ways in which space technology could improve the delivery of medical care to remote sites and disaster-stricken areas. The list of participants (including specialists in communications, medicine, and public policy) and the agenda give a ready indication of the diversity and range of experience of the interested organizations and individuals, and demonstrate the rich variety of ways in which the emerging field of telemedicine may contribute to the alleviation of human suffering.

The conference focused in large part on the potential contributions of telemedicine within two major areas of endeavor—disaster medicine and remote health care. In most cases the protocols and technologies will be identical, similar, or complementary, and, as the conference participants emphasized repeatedly, it would be most effective if the infrastructure emplaced for the routine practice of telemedicine could be modified, if and when necessary, for disaster medicine. "Disaster" was defined as a natural event, industrial or technological accident, or military conflict where human death and injury, property destruction, and environmental damage overwhelm local resources. The challenges for remote health care include delivery of care to rural areas and extreme environments (such as the Antarctic), oil rigs, battlefields, and, of course, space.

The papers contained herein document the conference and provide an overview of the state of the art of telemedicine. This introduction briefly highlights prior experience in telemedicine, explores the challenges for future telemedicine systems, and previews a venture in U.S./Russian cooperation that is developing as a follow-on to the U.S./U.S.S.R. Telemedicine Spacebridge.

EXPERIENCE

The National Aeronautics and Space Administration (NASA) is particularly interested in the advancement of telemedicine, since the agency is in the unique position of providing health care to crews in the most remote of environments, space. As described in the paper by Huntoon, Schneider, and Karamanos, NASA's use of medical telescience during the infancy of the U.S. manned space program focused on monitoring astronauts' basic vital signs. Mercury and Gemini crews were monitored by voice communications and transmission of blood pressure, respiratory rate, body temperature, and electrocardiogram data. Metabolic expenditure was monitored during extravehicular activities in the Apollo missions. With the advent of Skylab, telescience was expanded to include downlinking of data from in-flight medical investigations.

The Space Shuttle era requires more intensive biomedical monitoring. Crew health is assessed daily. Ground-based NASA flight surgeons track crew health through biomedical monitoring and daily private medical conferences, and are responsible for supporting the crew in the event of a medical emergency. Communications with the Space Shuttle consist of two-way audio and data transmission and video downlink via the Tracking and Data Relay Satellite System. Space-to-ground data transmission supports experimentation on dedicated biomedical Shuttle missions, as well. Telemedicine capabilities are used to address issues of space-flight physiological deconditioning, radiation exposure, confinement, and to augment the limited medical resources onboard spacecraft.

The upcoming Space Station Freedom's Health Maintenance Facility will enhance onboard medical capabilities and make even greater use of telemedicine during extended stays in orbit. As exploration missions arise in the future, it will be crucial to have established telemedicine systems available for crewmembers to receive medical consultation, since in many cases a swift return to Earth will not be possible in an emergency.

The United States' first venture into the use of satellite-based communications systems to provide long-distance medical consultation on Earth involved delivery of care to remote villages in Alaska during the early 1970s. This project utilized NASA's Applications Technology Satellite (ATS-1), and was sponsored by the Public Health Service.

Between 1973 and 1978 a project initiated in part as a testbed for space technology brought telemedicine to the remote Papago Indian Reservation in the Sonora Desert of Arizona. This demonstration, known as Space Technology Applied to Rural Papago

Advanced Health Care (STARPAHC) and described in Dr. Pool's paper, was jointly sponsored by NASA and the Indian Health Service. The goal was to test health care systems that would lend insight into systems envisioned long duration space missions. A mobile health clinic was outfitted with state-of-the-art health care equipment and staffed with a physician's assistant (PA) and laboratory technician. The capabilities tested included advanced bioinstrumentation, computers, and video. The PA administered medical care under the supervision of physicians based remotely in Sells, Arizona. These physicians made diagnoses and recommendations for treatment based on the clinical data transmitted to them.

As discussed in Dr. House's paper, Canada made strides in the use of telemedicine throughout the late 1960s and early 1970s. Using Canada's Hermes satellite, the Telemedicine Centre of Memorial University of Newfoundland (MUN) established one-way video and two-way audio links with four hospitals, initially for educational programs. Since 1978, Memorial's Teleconference System has continued to link numerous Canadian communities, using telecommunications technology to provide medical consultation nationwide. In an experimental program using the Anik B satellite in 1980-81, MUN tested a hybrid system combining terrestrial and space communications technology. In one phase of the experiment, an oil rig's sick bay was connected via satellite to the emergency department of a tertiary care hospital. Among the technologies employed in both of these Canadian programs was slow-scan television, with applications in radiology, nuclear medicine, and ultrasound.

Canada also has been a major participant in international telemedicine. In the 1980s, under Project SHARE (Satellites in Health and Rural Education), teleconference links were established between MUN and universities in the East African cities of Nairobi and Kampala. SHARE was later expanded to cover six Caribbean countries. The system was used for education, medical consultation, and transmission of biomedical data.

TELEMEDICINE SPACEBRIDGE

In December 1988, a severe earthquake struck the Soviet Republic of Armenia, resulting in 25,000 early deaths and over 125,000 casualties. The Telemedicine Spacebridge was proposed by the co-chairs of the NASA U.S./U.S.S.R. Joint Working Group on Space Biology and Medicine. The Spacebridge employed satellite telecommunications to effect medical consultation among U.S. medical centers and physicians in Armenia. Although several previous telemedicine projects had provided intercontinental clinical consultation and education programs, Spacebridge marked the first

interactive video telemedicine effort to provide medical support after a disaster. It remains the most significant example of international telemedicine cooperation to date.

Two-way audio and one-way full motion color video (from Armenia), and data and facsimile transmission were utilized to communicate between the Republic Diagnostic Center of Yerevan, Armenia, several regional Armenian hospitals, and the four participating American medical centers (Uniformed Services University of the Health Sciences (Bethesda, Maryland); Texas Medical Center (Houston, Texas); LDS Hospital (Salt Lake City, Utah); and the Maryland Institute for Emergency Medical Services Systems (Shock-Trauma)).

Clinical medical areas addressed during the consultation sessions included infectious disease, surgical intervention, burn treatment, epidemiology, orthopedics, and neurology. Psychiatric consultations were also given, addressing disaster-related topics such as post-traumatic stress syndrome, loss of or separation from family, and the effects on medical relief workers of the daily stress of working under duress amidst wide-ranging destruction and human carnage.

While the Spacebridge was in operation in Armenia, a second disaster struck the U.S.S.R. Two trains passing each other in a cloud of natural gas from a leaking pipeline triggered a gas explosion near the city of Ufa in Northern Russia. Hundreds of passengers were killed, with others suffering burns and trauma. The Spacebridge was promptly extended to Ufa, providing swift medical support for this second disaster.

As reviewed in the paper by Houtchens et. al., during Spacebridge's 3 months of operation, over 400 American and Soviet medical professionals participated in clinical conferences. Of the more than 200 cases discussed, 25 percent of diagnoses were altered, with many modifications in diagnostic studies and treatment plans also formulated. Spacebridge truly demonstrated that effective, interactive telemedicine consultation can play a major role in the aftermath of a major disaster.

TELEMEDICINE AND INTERNATIONAL RESPONSE TO DISASTERS

The Spacebridge revealed a number of important lessons for the international practice of telemedicine. For example, it took several months for the necessary bilateral agreements to be completed before consultations could proceed. Clearly, global telemedicine agreements and organizations, not to mention the technological infrastructure, must be in place if we are to respond quickly to disasters. This must be achieved by utilizing telemedicine internationally on a more routine basis, with issues of international law, liability, and responsibilities for cost and implementation resolved in advance.

There was a consensus at the conference that telemedicine capabilities for disasters and emergencies should indeed build upon existing infrastructures, maximizing the use of in-place systems and resources. Conference participants emphasized that telemedicine systems should be used routinely under non-disaster conditions, and that adequate technical training is a primary requirement. The need to extensively train technicians and physicians to operate a telemedicine system in the acute phases of a disaster would diminish that system's effectiveness. Moreover, effective training would ensure that consultants have at least a working knowledge of the culture, sociology, and environmental conditions of the region they will serve, all of which could influence diagnosis or treatment. Thus, telemedicine protocols should account for the inevitable differences in expertise and experience among physicians in individual nations. As Dr. Clemmer and others point out, standardization of protocols can improve communication in the face of cultural and language differences, assist decision making, protect against liability, promote the evaluation of new technologies and therapies, reduce costs, and aid quality assurance.

The international, coordinated response to the Armenian earthquake emphasized the need for prehospital emergency medical services infrastructure. The ability to resuscitate crush injury victims with intravenous crystalloid fluids, for example, is vital to helping reduce the incidence of renal failure from myoglobinuria. Efforts must be made to educate communities to allocate resources to develop prehospital medical service to the best of their ability in view of economic limitations. An in-place network of mental health services and psychological support systems is necessary to help both the local population and relief workers deal with overwhelming stressors.

A major issue to be resolved for the practice of telemedicine across international boundaries, with special ramifications for disaster medicine, is that of organizational involvement. Certainly there are roles to be played by the United Nations (including the U.N. Department of Humanitarian Affairs, the World Health Organization, and the International Telecommunications Union), the International Red Cross and Red Crescent Society, and many others. The entanglements of international law, bureaucracy, and the regulatory morass were cited as major obstacles by many conference participants. For example, which nations or organizations can or should pay for the creation and operation of a permanent telemedicine infrastructure? Who will operate it in times of disaster? What is the most effective chain of command? What are the implications of the international laws (or lack thereof) that govern communications systems? What are the proper ways to handle interfaces with individual governments, particularly in times of national emergency, when widespread injuries and property damage have severely stressed local resources and decimated existing social and governmental structures?

The commercial application of telemedicine was another future direction discussed at the conference. It was generally agreed that the expansion of telemedicine in private practice will depend largely on demonstrating the "value-added" dimension, i.e., reducing/controlling costs and improving care. Easing access to specialists may serve as an example here, especially when patients cannot travel or are geographically isolated. The Medical College of Georgia currently operates a telemedicine system that allows physicians to consult remotely with rural patients, with a PA on site. Other possibilities include nursing homes, correctional facilities, oil rigs and cruise ships, military bases, and polar stations: Telemedicine may reduce critical delays in health care in most of these instances.

In exploring these possibilities, we need to make intelligent use of the limited financial resources available for cooperative efforts, and we must educate the public and policy makers as to the tremendous potential for telemedicine. Health care providers must be instilled with greater confidence in informatic systems that retain many of the "personal" elements of care delivery through remote interaction with patients.

FUTURE DIRECTIONS

Based on the success of the 1989 U.S./U.S.S.R. Spacebridge, the Telemedicine Implementation Team of the the First U.S./Russian Joint Working Group on Space Biomedical and Life Support Systems met during the summer of 1992 in Washington, D.C., to develop plans for a follow-on program known as the Telemedicine Demonstration Project (TDP). The TDP is slated to begin in March 1993, and will continue for 6 months. One 4-hour session will be conducted every other week, originating on a rotating basis from the three main U.S. medical institutions participating in the program: Uniformed Services University of the Health Sciences (Bethesda, Maryland); Texas Medical Center (Houston, Texas); and LDS Hospital (Salt Lake City, Utah). These centers will be connected to a clinical hospital in Moscow and the Moscow Medical Academy, with plans for future expansion to other regional hospitals in Russia.

Communications for the TDP will utilize both U.S. and Russian satellites. The U.S. sites will uplink to a U.S. domestic satellite (DOMSAT), which will then downlink to an earth station at NASA's Lewis Research Center. Signals will then be transmitted from Lewis to the Russian "Loutch" satellite for the transatlantic link, and subsequently downlinked to the Moscow central station. The system will include audio, facsimile, and two-way color video transmission.

The TDP will provide expert consultation between the U.S. and Russia in clinical and preventive medicine, disaster and trauma management, epidemiology, cancer

treatment/research, surgery, and public health. The agreement calls for the medical experts from both countries to exchange visits and acquaint themselves with the facilities and capabilities of the institutions with which they will interact.

Hopefully, the TDP will be a forerunner of additional telemedicine cooperation between the U.S. and Russia. It will serve to strengthen the scientific and cultural exchange between the two nations, expand on technologies that can develop into international medical exchange programs, and provide NASA with experience in distant health care delivery systems, which is important for Space Station Freedom and subsequent exploration missions.

CONCLUSION

Telemedicine is a new and dynamic field, and we are as yet in the first stages of exploring its possible applications. With the growing demand for broader delivery of health care and more attention to cost-effectiveness (and with economic restraints a fact of life), it is highly likely that telemedicine will play an ever increasing role in medicine. The health care industry has a total value in excess of \$800 billion dollars per year; any increase in cost-effectiveness realized by telemedicine will be significant. Creative thinking and careful planning will be required as we further integrate telecommunications technologies into health care, both routine and disaster-oriented. The papers contained herein give an overview of the challenges we face.

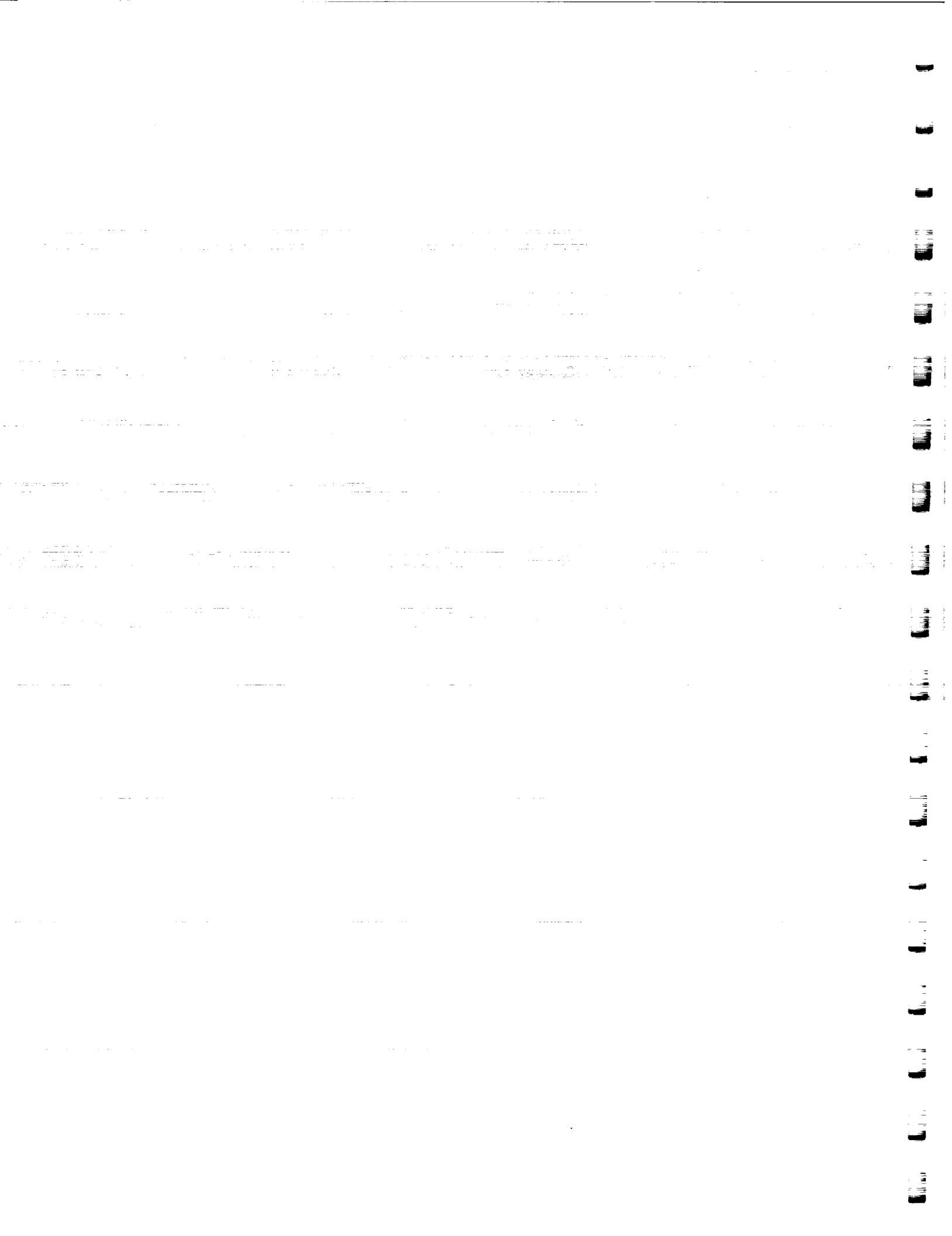
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Welcoming Address / Introduction to the Conference

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Director, Life Sciences Division
National Aeronautics and Space Administration
Washington, D.C.**

**Harry C. Holloway, M.D.
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Uniformed Services University of the Health Sciences**

I would like to welcome you to the International Conference on Telemedicine and Disaster Medicine. Our intention when we were formulating plans for this conference was to convene a group of people who were playing significant roles in the evolution of telemedicine as a medical specialty. Specifically, we wanted to gather policymakers to discuss the current and future applications of telemedicine technology to disaster medicine, public health and epidemiology, and remote health care.

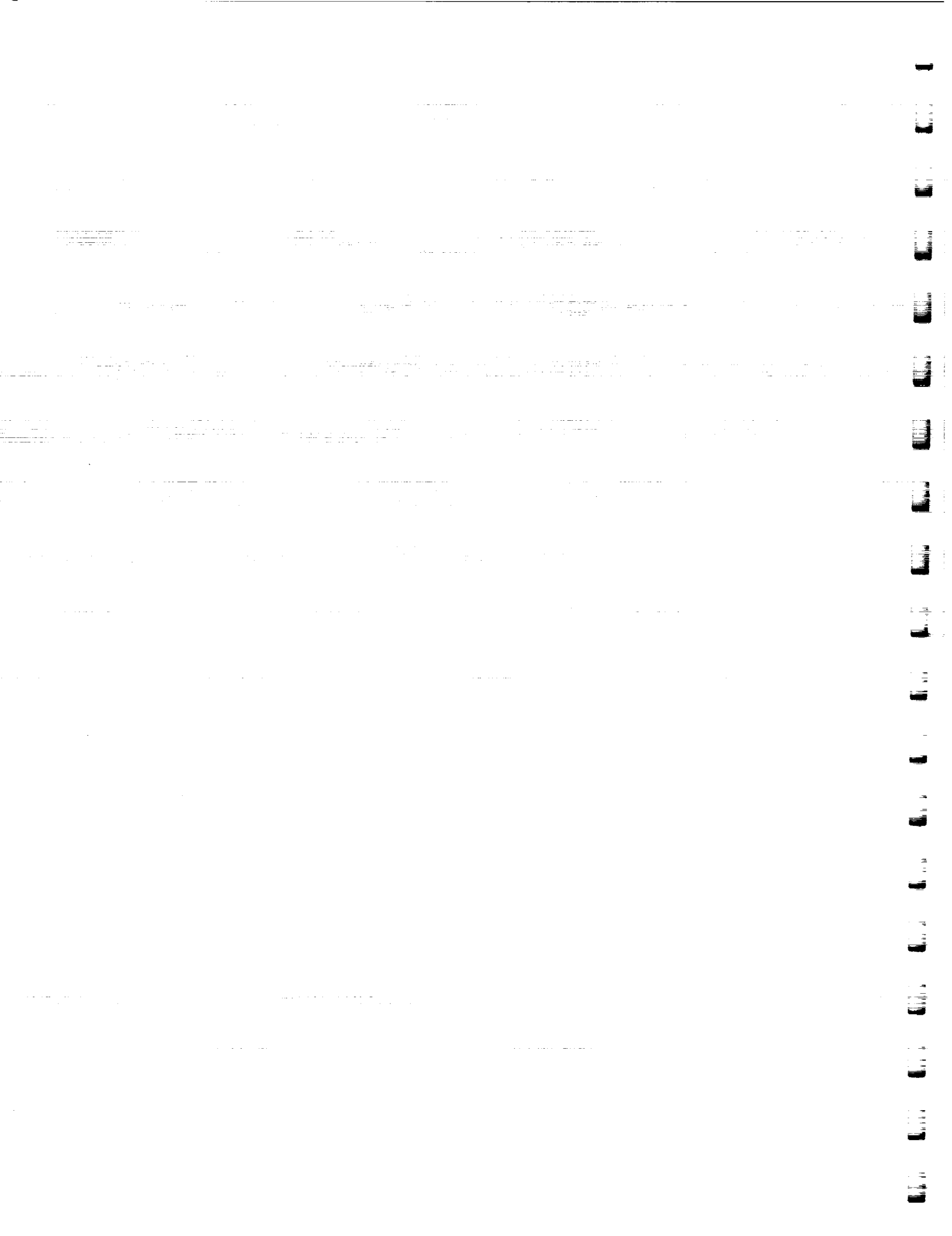
As you would well imagine, NASA's interest in remote health care results from our responsibility to provide quality health care services to astronauts undertaking space travel. Where our current Shuttle missions involve flights of only 7-10 days, discussions are under way regarding the possibility of 90-day Shuttle flights, which would involve docking the Shuttle to certain elements of the planned Space Station Freedom. These flights, and future flights being discussed in the context of exploration missions, would involve stays of up to 6 months or more in microgravity or the partial gravity (.17g) of the Moon. Telemedicine will have a key role to play in supporting medical operations for those missions in that it will not be possible to place on board spacecraft all the medical resources that we would optimally need. As you know, weight, volume, power, and crew time are very precious resources on board any spacecraft. Telemedicine support allows those on-board capabilities to be used in an optimal manner. Future interplanetary missions, such as to Mars, will involve distances of several hundred million miles—on this type of mission, due to the communications delay of up to 20 minutes, only non-emergency medical consultations will be possible. These circumstances strongly suggest the need for a high degree of self-sufficiency in exploration medical systems.

NASA's experience with telemedicine dates to the 1960s, when the need for biomedical monitoring of early space crews drove the development of biotelemetry systems. Future missions will require the further evolution of compact medical delivery systems, which will be supported by a crewmember physician, an integrated telemedicine capability, and possibly computer-aided

medical diagnosis. In addition, advanced medical care systems for space will clearly benefit from ongoing developments in the terrestrial medical community, such as improved fiber optic endoscopes, and laparoscopes. The increasingly common use of these devices to do endoscopic or laparoscopic surgery raises the possibility that these same procedures could be performed using a remotely located surgeon. Other advances, such as the development of compact, digital radiographic systems, will allow simultaneous in-flight creation and ground transmission of medical images. These advances will allow the Crew Medical Officer, whether he or she is a physician or allied health personnel, to effectively deliver sophisticated medical care to a sick or injured astronaut.

Over the next several days, we hope to challenge all of you to think of telemedicine from a new perspective. The evolution of telemedicine as a distinct medical speciality appears to be gathering momentum by providing solutions to a crucial problem in contemporary health care. This problem is the poor distribution of medical care specialists in certain geographic areas. Or, in some instances, the complete lack of physicians in certain locales. In this latter case, a physician's assistant, with telemedicine support, can deliver the caliber of care normally associated with the presence of a physician.

While certain sponsors of specialized, remote operations, such as the oil industry and NASA, will routinely provide telemedicine support for their operational platforms regardless of cost, the truer test of telemedicine lies in its potential to facilitate health care for a broader populace now underserved by medical care providers.



Remarks Delivered at the International Telemedicine/Disaster Medicine Conference

**Vice Adm. Richard H. Truly
NASA Administrator**

On behalf of NASA I would like to welcome you to this conference. Over the years, practical applications from NASA's space science programs have yielded tremendous benefits to people around the globe—in such ways as weather forecasting, enhanced communications, and resource monitoring, to name a few, and I'm especially excited about the contributions of NASA's space research and technology to the fields of disaster medicine and telemedicine.

NASA routinely uses telemedicine now to support its manned space flight program. Exciting new developments in the field are helping to build the foundation for even more ambitious and far-reaching uses of telemedicine in space. I'm talking about Space Station Freedom, and manned flights to the Moon and Mars, where our astronauts will be hundred of thousands, or millions, of miles from a doctor.

We have learned that there are many similarities between administering quality health care in space and in remote areas on Earth. In both cases, the physician must treat patients under very difficult conditions, where clinical equipment is limited, where there is a lack of adequate facilities and limited access to medical specialists.

Disaster medicine is a specialty that provides medical care to victims who have survived catastrophes and who, without such aid for their injuries, would suffer tremendously or possibly die. Telemedicine utilizes telecommunications to enable medical consultations over great distances, allowing us to provide a high level of medical expertise and capabilities to geographically remote areas.

Perhaps the most dramatic example of telemedicine was the U.S.-U.S.S.R. Spacebridge—a joint relief effort initiated by NASA to provide prompt medical relief for victims of the 1988 earthquake in Armenia. The Spacebridge was later expanded to aid the victims of a railway explosion outside the Soviet City of Ufa. Linked by satellite, doctors in the U.S. and the U.S.S.R. were able to combine their skills for the relief of hundreds of victims during the existence of the Spacebridge. Over 400 physicians and medical personnel from both countries participated in this activity, treating a wide range of injuries, along with psychiatric and public health problems. The success of the Spacebridge provided invaluable lessons in the operation of a complex telemedicine consultation network, which should prove to be extremely useful in future emergencies.

These recent successes and the promising future of telemedicine have developed partly through the application of research into communications, remote sensing, and biomedical research, both on the ground and space-based.

The space program has stimulated advances in biotelemetry, a method first used to monitor astronauts' vital signs during Project Mercury. Our need to gather physiological data, convert them into signals and send them to monitoring personnel at remote locations, has led to advances including miniaturization of equipment, computer enhancement, and improvements in the character of the signal.

The practice of telemedicine was further developed through the STARPAHC Project, or Space Technology Applied to Rural Papago Health Care, where medical data of patients in the remote Papago Indian Reservation in Arizona were transmitted, via microwave communications network, from a mobile clinic to a distant base of operations. Hospital-based physicians monitored the data, made diagnoses, and prescribed treatments.

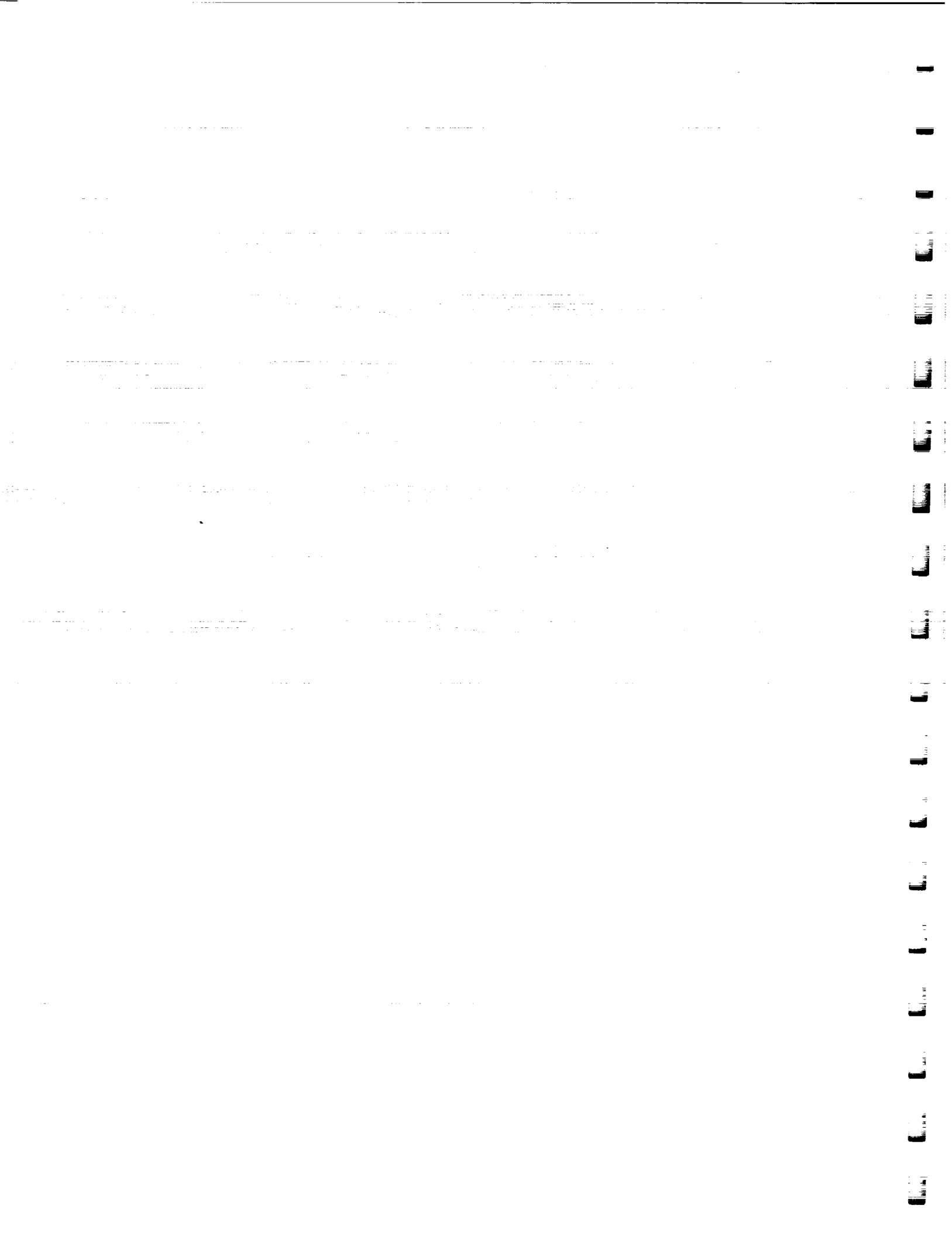
Another promising application enabled by our vantage in space is the ability to monitor subtle changes in the biosphere. Since 1985 NASA's Biospheric Monitoring and Disease Prediction Project has been using remote sensing technology in an effort to model the relationship between malaria spread and its environment. Malaria remains a serious health problem worldwide. The goal of this project is to develop models that will improve our ability to predict future outbreaks.

A host of spacecraft have been designed to fundamentally improve our understanding of how the Earth functions as a system. The recently launched Upper Atmosphere Research Satellite will vastly increase our understanding of the dynamics and chemistry of the Earth's upper atmosphere. The Laser Geodynamics Satellite, a joint project between the U.S. and Italy, will continue important measurements needed for research on plate tectonics and ocean tides, and thus could potentially help in predicting earthquakes and sea-level change over the coming decade.

It is inevitable that breakthroughs in research and technology resulting from the Space Shuttle missions and later from Space Station Freedom will continue to generate advances which will benefit all of the human race.

I am hopeful that these past few days will lead to new, innovative applications of telemedicine, and NASA is proud to play a continuing role in these important endeavors. Those of you participating in this conference face enormous challenges in providing care and relief for the unfortunate victims of natural disasters. I applaud your efforts.

10



Medical Informatics and Telemedicine: A Vision

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I. INTRODUCTION

- A. On April 12, 1961, Yuri A. Gagarin rode the spacecraft Vostok 1 for man's first trip into space. This trip was a testimony of man's commitment to a vision. Today I would like to convey to you another vision; a vision of what we are about to embark upon in medicine. I hope we can generate a commitment toward this vision as we have towards so many others.
- B. The vision is how medical information systems are going to impact the way we deliver medical care in the future.

II. The goal of Medical Informatics is to improve care. This requires the commitment and harmonious collaboration between the computer scientists and clinicians and an integrated database.

III. The integrated database receives input from all departments and, where feasible, is automated from bedside and laboratory devices.

- A. Examples: Infusion pumps, Ventilators, the medical information bus.

IV. Medical Information Systems today are used primarily to:

- A. Retrieve, process, organize and display data for the healthcare provider.
- B. Alert the healthcare provider of dangerous situations.
- C. Provide a database for research efforts.

V. The real power of medical informatics is much greater.

- A. It is a tool which can foster the standardization of care. With standardization comes enormous power to improve care while reducing costs.
 - 1. The process of computerizing a standard in itself improves care.

- a. The initial logic for decision making is developed by experts who are required to publish for review and defend their decisions to their peers.
 - b. Once developed, the initial logic decisions are implemented by feeding the decisions to the healthcare providers in a clinical setting for validation prior to carrying them out. Any overrides of the protocol are logged and reviewed in regularly scheduled iterative sessions. When overrides are deemed justified they become the stimulus to modify and strengthen the protocols. Thus the standard is constantly improving. If the override cannot be justified then the healthcare provider is informed that they are practicing outside the computerized standard.
 - c. Example: The ECCO₂R Study.¹
2. Standardized care is a powerful tool for evaluating and directing new therapies.
 - a. Once a standard is set, the evaluation of any new drug, device or process of care is greatly facilitated and more credible.
 - b. Outcome evaluation and cost-effectiveness becomes more scientific and reproducible.
 - c. The role of the new therapy can be better defined.
 - (1) Example: The role of ECCO₂R
3. Standardization provides a platform for new and exciting methods of automated, real time quality assurance (QA).
 - a. Because there is a standard, breeches can be monitored and alerted via the computer. These breeches can be reviewed expeditiously, and where indicated, immediate feedback given to the care provider. Thus prospective quality assurance can be carried out for every patient.
 - b. Example: LDS Hospital's Respiratory Therapy programs.²
- B. Standards assist and facilitate healthcare providers in decision making.
 1. It allows the healthcare provider to immediately know the standard.
 2. On-line epidemiology allows many of the computer decisions to be based on real time scientific data.
 3. It can prospectively feed back costs of various decisions to the care provider at the time of ordering.
 4. It can remind and prompt timely care decisions.

5. Examples:
 - a. Antibiotic assistant program.³
 - b. Prophylactic antibiotic study.⁴
 - c. The adverse drug reaction study.⁵
- VI. Today, using integrated databases, computer scientists and clinicians are beginning to step through this window of opportunity. They are just now launching the attack on the inconsistencies in the process of care via the application of medical informatics.
- VII. This is just the tip of the iceberg. What is being done today is to this vision what the Mercury spacecraft was to the space program. We are in the infancy of our journey.
- VIII. Medical Informatics' link to telemedicine will vastly expand the vision for improved healthcare universally.
 - A. One of the most difficult problems is how to improve care in areas which have sparse resources and sporadic physician coverage; such as in rural areas, disaster and battle scenarios, and in remote areas such as the Antarctic, ships at sea, and space missions.
 - B. There are three major problems in delivering healthcare in these areas:
 1. Lack of readily available local expertise and technology.
 2. Poor communications with experts in a timely fashion.
 3. Lack of ability to monitor, collect data and provide quality assurance in these areas.
 - C. By linking medical informatics systems to rural and remote areas through telemedical links the same standards of decision making can be applied everywhere. In addition, the epidemiologic data could be retrieved and continuously updated in real time for improved decision logic, quality assurance, and public health purposes.
 - D. Example: IHC Transurethral Prostatic Resection Study.⁶
 - E. Such technology will also allow us to share the process of care between nations and to include third world countries.
- IX. This is a glimpse of what is about to happen. The potential impact of improving the process of care is equal to, and probably more important than, the marvelous advancements we are seeing in the basic sciences.

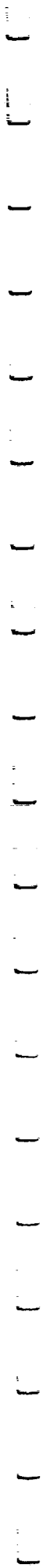
- X. High quality care is less costly care. Given our current economic crisis in medical care we must focus on quality. We must evaluate and validate new technology and its relationship to the process of care and its cost-effectiveness. Standardization also allows the expense of care to be evaluated and as cost reduction methods are implemented, to evaluate any change in outcome and therefore assess cost and benefit. Medical informatics gives us a powerful tool to address these issues.
- XI. Standardized care may allow protection against legal action where undesirable outcomes occur despite practicing within the standard. The potential impact of this on healthcare costs could be dramatic.
- XII. The **BARRIERS** to realizing this **VISION** are great.
- A. First, one of our major restraints is that current funding for this vision is very difficult to find. Outcomes research funding today is not a leading priority of any agency.
 - B. Secondly, we need visionary men and women, champions, people with determination akin to President John Kennedy's commitment to the space program.
 - C. Thirdly, we need ethical, caring healthcare providers who are willing to admit they frequently do not know what the best therapy is, and who are agreeable to abandoning their stylistic differences and committing to discovering truth, and discovering better ways to care for patients at reduced costs.
 - D. Lastly, we need a balance in research between the basic sciences and clinical applications. We need to learn how to more effectively apply the current and future knowledge to benefit mankind worldwide.

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**The Canadian Experience:
Using Telemedicine for the Support of Medical Care at Remote Sites**

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INTRODUCTION

While the majority of Canadians live in a narrow strip about 200 miles wide just north of the 45th parallel, a significant proportion of the population lives in non-urban, remote and sometimes isolated areas. Given this widely dispersed population, the provision of health services has always been a challenge.

A list of non-urban health needs include the following: consulting services; clinical laboratory resources; investigative techniques (e.g., EEG, radiology, ultrasound, nuclear medicine); continuing education for physicians, nurses and other health professionals; teaching and training programmes for administrative and support staff (dietary, housekeeping, maintenance); community health education and improved general education for health workers and families.

For nearly three decades physicians and other health care professionals in the United States and Canada have been exploring the application of telecommunications to health care in rural and remote areas. The terms telemedicine and telehealth are used interchangeably to describe this activity. Here the prefix "tele" refers to distance and now includes all types of communication over distance that support health care and health educational programmes. Actually, telemedicine is as old as the telephone, which is still the most widely used communications technology in health care.

EARLY DEVELOPMENTS

The United States' Applications Technology Satellites ATS I and ATS VI were used for a number of impressive demonstrations in the late 1960s and early 1970s; the Communications Technology Satellite (called Hermes in Canada), which was a joint American/Canadian project, was used in experiments in Canada as well as in the United States. The Moose Factory experiment at the University of Western Ontario in London demonstrated the value of live television and interactive audio systems in the provision of consultations and transmission of medical data,

particularly x-rays. The WAMI (Washington, Alaska, Montana and Idaho) project of the University of Washington in Seattle was mainly an educational project. For a number of years there has been distance monitoring of cardiac pacemakers, the transmission of electrocardiograms, and one or two tele-EEG services.

CTS Satellite (Hermes). Memorial University of Newfoundland (MUN) has had a tradition of outreach since it was established and was an early participant in the Canadian Space Programme. The Telemedicine Centre's experiment with the Hermes satellite involved a one-way television/two-way interactive audio configuration. Four remote hospitals were linked to the University in St. John's. There were 150 hours of programming over a period of 3 months. There was also a telephony channel which we used for a slow scan television trial.

Continuing education courses for physicians and other health professionals were offered, administrative and committee meetings were facilitated, and there were limited numbers of transmissions of medical data, including electrocardiograms (ECG), x-rays and other images by slow scan television (SSTV).

While this project demonstrated clearly the effectiveness of one-way live television and interactive audio, it was concluded that most of the educational material could have been delivered by audio alone. It was clear that multipoint television with interactive audio would not be economically feasible in the province for the foreseeable future. Efforts were turned to the development of a mainly terrestrially based teleconference system, which I will describe later.

Anik B Satellite. After Hermes, Canada's Anik B satellite was launched and there were a number of health and education experiments. Memorial University's Anik B experiment was in two phases.

Phase I. The objectives of the first phase were (1) to design and demonstrate a hybrid terrestrial/satellite narrowband network to expand the existing land-based Teleconference System (TCS) to more remote communities, and (2) to evaluate the effect of a dedicated telephony channel link between a drillship sick bay and an emergency department, in a tertiary care hospital, on offshore medical services.

The hybrid satellite/terrestrial network, which linked three land-based sites to the existing teleconference terrestrial network, functioned successfully throughout 1980 and 1981.

Phase II. In this phase, a manually steerable terminal, designed by the federal Department of Communications (DOC), was utilized in conjunction with dedicated audio channels on the Anik B satellite for transmission. Audio equipment and an SSTV unit were placed on a drillship. Although successful SSTV and audio transmissions were received while the drillship was under sail, mechanical problems with the terminal precluded completion of the offshore activities in this phase.

During Phase II, which was a joint project with DOC and the Newfoundland Telephone Company, a prototype gyroscopically stabilized terminal designed by DOC for use offshore was placed on a semisubmersible oil rig. Through this terminal the rig had access to two dedicated satellite audio channels. One was used in a two-wire mode as a standard telephone link and the second, a dedicated four-wire circuit, linked the sick bay to the emergency department of a tertiary care hospital, as in the first phase. In this phase the rig medic was supplied with ECG transmission equipment, as well as audio and SSTV units.

Terrestrially Based Systems. From 1977 Memorial's Telemedicine Centre has directed its efforts toward the development of interactive audio networks for the delivery of educational programmes and the transmission of medical data. In developing Memorial University's telemedicine projects a number of guidelines were followed:

- Use the simplest and least expensive technology that will meet needs.
- Develop a flexible system.
- Involve users (participants, audience, clients) from the beginning of the project.
- Seek the support of administrative personnel in hospitals, clinics, and other agencies.
- Plan carefully for coordination of the system at all levels.
- Develop a consortium of users within and outside the health field.
- Plan for continuity of service beyond the demonstration project.
- Include evaluation.

Memorial's Teleconference System. Established in 1978, Memorial's Teleconference System is a province-wide audio network linking 170 sites in 80 communities. This is primarily a four-wire network and can be divided into seven separate divisions for simultaneous programming. Twenty communities use a two-wire, dial-up configuration. A 20-port teleconference bridge, located at the Centre, accommodates these sites.

The two-wire bridge allows the inclusion of external resource people in conferences, permits access to other teleconference networks, and provides a link for international activities. This bridge can be divided into four sections, each of which can be joined to any of the four-wire circuits.

The teleconference network, with a staff of 10, is financially fully self-supporting with costs shared on the basis of use patterns. In 1990, there were 5,000 hours of programming.

MEDICAL DATA TRANSMISSION

Slow Scan Television. Slow scan technology has been available for 15 years and permits the transmission of a picture over an ordinary telephone line. A television camera captures a single

frame of a television transmission and converts this to an analogue signal for transmission over a period of time (15-70 seconds depending on the resolution required). This technique is also called freeze-frame or captured-frame video. With the advent of digital equipment, there has been an increase in image quality and a shortening of transmission time. Resolution offered by earlier equipment such as that used in the offshore telemedicine experiment, was considered by many radiologists as unacceptable, although promising. Current digital equipment appears to be more satisfactory for many types of images. Slow scan television is now in a pre-operational mode among three remote hospitals and the University's Centre, with applications in radiology, ultrasound, nuclear medicine, and clinical consultations.

Electroencephalography (EEG). Six peripheral hospitals are currently transmitting a total of approximately 1,200 EEG tracings per year to the University's main teaching hospital. Remote equipment consists of an electrode cap and a transmitter. A receiver converts the multiplexed eight channels of the EEG which, transmitted on the four-wire telephone network or by regular two-wire, dial-up lines, are recorded on a standard EEG machine. At the remote site technical work is done by an ECG technician, x-ray technician or a nurse. Training of the remote technician requires about 10 days in the EEG department of the urban hospital. This EEG service, after 8 years of experience, is acceptable to referring physicians, hospital administration, and electroencephalographers. Examinations can be done as an emergency, urgently or routinely. Referring physicians receive reports immediately if required. Approximately 7,000 tracings in all have been transmitted in the past 9 years.

Electrocardiography (ECG). A number of remote sites have ECG transmitters which allow a standard ECG to be transmitted, around the clock, to the ECG department or coronary care unit of the University hospital. This is an inexpensive service, which can be used as a clinical laboratory service or as part of a consultation.

Telewriters. For education and training, audio teleconferencing can be greatly enhanced by the use of this computer-based system. This electronic "blackboard" is of particular value where real time visual information, such as writing, printing, symbols, diagrams and graphics, are required to support a given lecture or presentation. Telewriters are equally effective for business and research meetings. Freehand writing and graphics can be presented and exchanged, annotated, altered, and discussed during a conference or teaching session. Telewriters are of particular value in distance teaching of mathematics, engineering, and physics as well as in other service applications, such as community health programmes.

Electronic Mail Project. Because the circuits of Memorial's Teleconference System are not used between 2200 hours and 0800 hours, it was logical to consider the automatic transmission of data between and among the 80 communities on the network. To this end, a computer software

programme was developed to permit compatible personal computers to deliver electronic mail (e-mail) messages throughout the system. This project is now in a pre-operational phase.

External Projects. In 1982, the Royal College of Physicians and Surgeons of Canada and the Toronto General Hospital jointly conducted a national teleconference trial project which lasted 2 years. All 16 medical schools in Canada were given a teleconference kit and access to a 20-port teleconference bridge. The objective of the project was to determine the value of teleconferencing at the national level in one health field. The project was jointly funded by the Royal College and the Donner Canadian Foundation. The project, which was done in collaboration with Memorial University, was followed by Telemedicine for Ontario, which is now called Telemedicine Canada.

INTERNATIONAL PROJECTS

International Satellite Organization (INTELSAT). Canadian medical academics, along with those from other countries, played a significant role in the development of the School of Medicine at the University of Nairobi, Kenya, in the 1960s and 1970s. Subsequent to this a MUN project, supported by the Canadian International Development Agency (CIDA), was initiated to provide support for the Paediatric Department at Makerere University in Kampala, Uganda. This was called the Child Health and Medical Education Programme (CHAMP).

In 1985 the International Satellite Organization (INTELSAT) and the International Institute of Communications established the Satellites in Health and Rural Education (SHARE) project to celebrate the 20th anniversary of the establishment of INTELSAT. The Telemedicine group at MUN saw this as an opportunity to establish a link not only between Nairobi and Kampala, but also to provide a teleconference link between those two East African cities and Memorial University in Canada. With the involvement and collaboration of Teleglobe Canada, Post & Telegraphs of Kenya and Uganda, and INTELSAT, a four-wire dedicated system was put in place in December 1985 with Nairobi, and with Kampala in February 1986. Funding, in part, for this project came from the Toronto Hospital for Sick Children's Foundation.

Programming—The system was used for teaching sessions, administrative meetings, transmission of EEGs, and a variety of other applications. The Hospital for Sick Children in Toronto and paediatric faculty of the University of Toronto contributed many programmes using the telemedicine teleconference bridge. The Janeway Child Health Centre in St. John's and MUN's discipline of paediatrics were responsible for the majority of programmes. EEGs were transmitted from Nairobi for 2 months and from Kampala for 10 months; approximately 100 tracings were transmitted and the majority of these were interpreted with confidence by electroencephalographers in St. John's.

In June 1986 the MUN SHARE project was extended to include the six Caribbean countries on the University of the West Indies Distance Education (UWIDITE) Teleconference System. These sites were accessed through the UWIDITE control centre at the MONA campus in Kingston, Jamaica. The technical configuration allowed the Telemedicine Centre to switch automatically the Teleglobe gateway signal between Africa or the West Indies as required. Because of the nature of the existing UWIDITE system there were some technical problems, but these did not interfere with active programming using voice and in many instances slow scan television. The four-wire dedicated link to the West Indies was terminated at the end of December 1986.

Subsequent to the SHARE project, MUN's Telemedicine Centre developed a radio-based teleconference system in Jamaica. The project was jointly carried out by MUN and the University of the West Indies (UWI) and was supported by the Canadian International Development Agency in the amount of \$625,000. The Jamaica network has been designed so that it can be interfaced with the existing satellite network that connects seven island countries. It is anticipated that this design will be used as a model for expansion of UWIDITE in other Caribbean islands. In addition to developing the technical system, MUN is cooperating with UWI in developing appropriate course design techniques for Jamaica.

Satellife. SatelliLife is a non-profit, international organization committed to using modern communication technologies to link medical centres and physicians throughout the world for information sharing. SatelliLife, with an international board of scientists and physicians, is an East-West partnership with offices in Boston and Moscow.

One of the projects of SatelliLife, HealthNet, will transmit medical information, including the contents of *The New England Journal of Medicine*, to five university medical libraries in East Africa using a low-orbit satellite called HealthSat. HealthSat was built by Surrey Satellite Technology Ltd. of Britain with the payload being owned by SatelliLife. The satellite (UoSat-5) weighs about 50 kg and makes a north-south orbit every 100 minutes. As it passes over a given point on the earth, signals can be sent to and received from groundstations. The messages are stored in the satellite's computer until the satellite, a few hours later, passes over the addresses elsewhere on earth. The groundstation consists of a radio, a modem, and a computer. Memorial has the North American gateway station for this satellite e-mail pilot project. E-mail messages received by terrestrial networks will be transferred manually to the satellite ground terminal. The satellite passes over a given point on the earth at least twice daily. There will be a 2-18 minute "window" during which time information will be received and sent to the satellite with delivery to other transmitting/receiving stations anywhere in the world. Obviously, the applications will be in areas where limited or no communication system now exists. HealthNet, the current project of SatelliLife, will have 15 terminals located worldwide with six in East Africa. This project has received financial support from a number of granting agencies.

It should be noted that amateur radio operators have been using this low-orbit satellite technology for some time and there are a number of commercial programmes in the planning stage or under development. Motorola with its plans for iridium and its 77 interconnected small satellites, and Russia with its "Small Sat" project, have certainly raised the profile of low-orbit communications. SatelLife's low-orbit satellite project is experimental and Memorial has an experimental license. It may be an understatement to say that it will be some time before the regulatory considerations governing low-orbit satellite communications.

Digital Communications Technology. While Canada has been slower than some other countries (U.S. and Scandinavian countries) to digitize its telephone networks, this process is now underway with substantial digitization expected by the mid-nineties.

With digitization it is possible to transmit large amounts of data without the need for broadband circuits. There has been an increasing use of intermediate bandwidth circuits (up to 2 megabits) in the U.S. and in Scandinavian countries. This technology is referred to as T-1. In June 1990 Nymo and Engum, in a presentation at an OECD conference in Kiruna, Sweden, described the use of T-1 technology to transmit medical data from remote to urban hospitals. The Norwegian Telephone Company had, by early 1991, a 30-point T-1 network with many sites having the capacity to transmit compressed video. There is currently an interest in a T-1 trial between Canada and Europe using the European Space Agency's Olympus satellite, which covers Eastern Canada with its 20/30 gigahertz "footprint." Memorial University will shortly have a 20/30 gigahertz terminal to access Olympus in Eastern Canada. This is expected to be used for telescience and space medicine projects between Europe and Canada. These may include telescience simulation experiments using the space station module at Noordwijk in the Netherlands and hyperbaric chambers at Memorial in St. John's. The projects will include teletraining and a range of data transmission to support science and health care in space. A relationship between Memorial and the European Astronaut programme in Cologne, Germany, is under development.

Currently, at Memorial we are jointly, with the Newfoundland Telephone Company and DOC, starting a terrestrially based T-1 project with several components, including health and education applications.

The provision of health care in space is of concern to space agencies internationally; and it is, in part, because of the European Space Agency's needs that the ESTEC projects mentioned above were supported. Canada has been involved in the NASA Space Station, and as a result of this, the Canadian National Research Council carried out a study in 1985 on the feasibility of Canadian participation in the development of the Health Maintenance Facility.

Broadcast Television. There is an increasing use of satellite television programming in the health field, especially to reach large audiences. A number of networks in the U.S., Canada, and Europe offer health education programmes to professionals as well as to other specific interest

groups. It seems likely that compressed video using codecs (encoder/decoder) will play an important role in health education in the future. The recent agreement on an international standard for codecs will undoubtedly stimulate international usage.

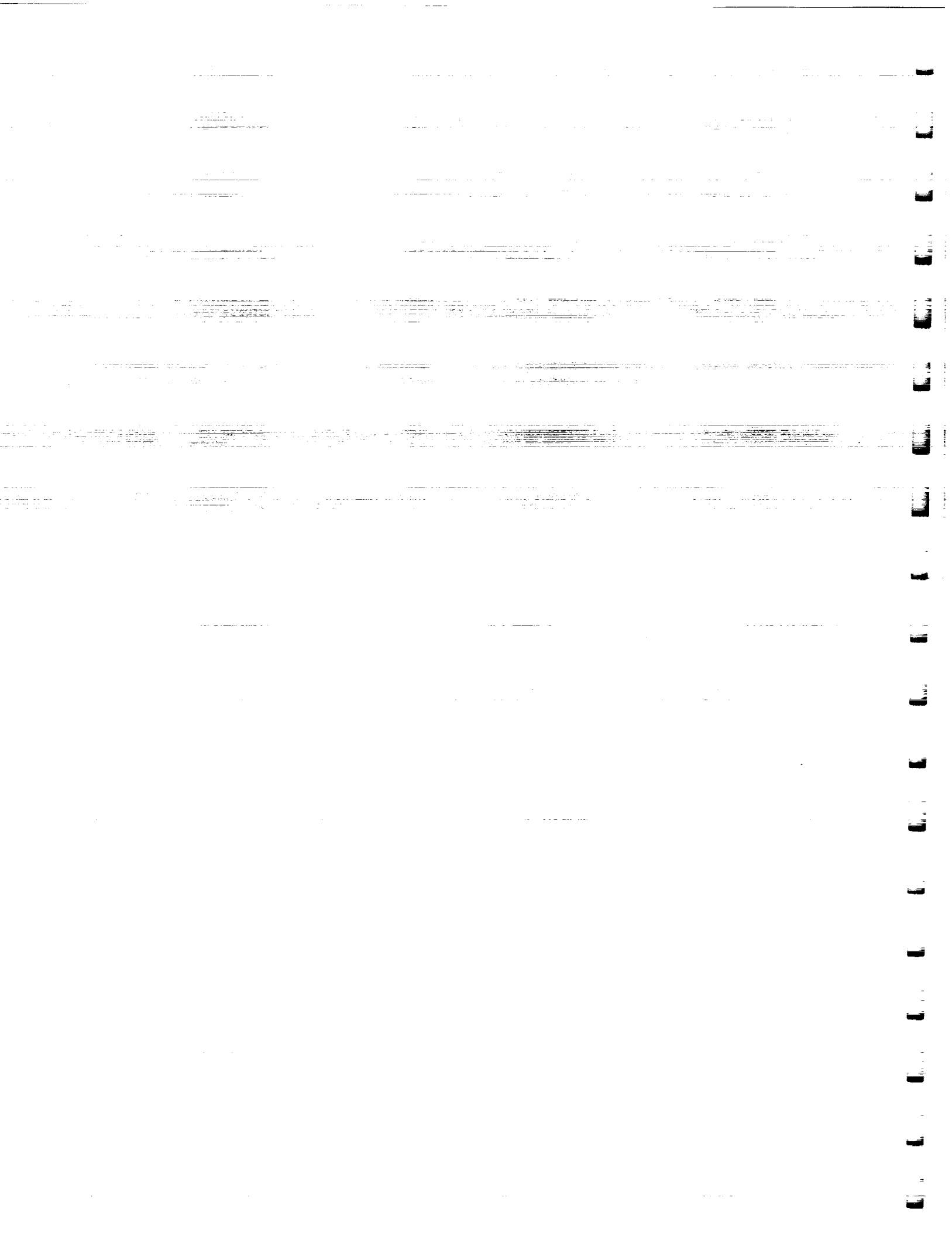
This technology is still relatively expensive; and audio conferencing and narrowband transmission of medical data will continue, for some, to provide the most cost effective method of supporting health needs in rural and remote areas.

CONCLUSION

Telemedicine and distance education programmes require the whole range of terrestrial and space-based communication systems. Only satellites can provide reliable communications in some geographic locations and offer the easiest method of providing international links.

Space research will most certainly contribute to the development of technology that will be of benefit not only for space activities, but also more broadly for terrestrial applications in health and education.

The range of telemedicine activities in Canada over the past 15 years has clearly shown its value in the health field. Despite this, the actual use of the technology, with a few notable exceptions, is limited. Health needs that can be satisfied by telecommunications technology are increasing, and it is expected that the next decade will see a more widespread application of telemedicine to non-urban, remote, and isolated areas.



**Telemedicine and International Disaster Response:
Medical Consultation to Armenia and Russia
Via a Telemedicine Spacebridge**

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ABSTRACT

Introduction: The Telemedicine Spacebridge, a satellite mediated audio-video-fax link between four U.S. and two Armenian and Russian medical centers, permitted remote American consultants to assist Armenian and Russian physicians in the management of medical problems following the December 1988 earthquake in Armenia and the June 1989 gas explosion near Ufa. **Methods:** During 12 weeks of operations, 247 Armenian and Russian and 175 American medical professionals participated in 34 half-day clinical conferences. 209 patients were discussed, requiring expertise in 20 specialty areas. **Results:** Telemedicine consultations resulted in altered diagnoses for 54, new diagnostic studies for 70, altered diagnostic processes for 47, and modified treatment plans for 47 of 185 Armenian patients presented. Simultaneous participation of several U.S. medical centers was judged beneficial; quality of data transmission was judged excellent. **Conclusion:** These results suggest that interactive consultation by remote specialists can provide valuable assistance to onsite physicians and favorably influence clinical decisions in the aftermath of major disasters.

INTRODUCTION

On 7 December 1988, the Republic of Armenia suffered an earthquake of massive proportions. With over 25,000 early deaths—including many health care workers, and over 125,000 survivors in need of medical attention—Armenia's crippled medical care system initially was overwhelmed (1). Wishing to utilize space communications technology to facilitate medical assistance in the aftermath of the earthquake, the co-chairmen of the U.S./U.S.S.R. Joint Working Group on Space Biology and Medicine proposed a satellite mediated medical telecommunications network to permit physicians at U.S. medical centers to provide consultation to physicians in Armenia. This project was called Telemedicine Spacebridge. On 4 June 1989, near the city of Ufa in northern Russia, 2 trains, each carrying over 500 passengers, passed each other within a cloud of natural gas arising from a pipeline leak. The gas exploded; most of the passengers in one train were killed outright; hundreds of passengers in the other train—many of them children returning from summer camp—suffered severe burns. The Spacebridge was extended to permit American burn specialists to provide remote assistance to Russian physicians caring for burn victims in Ufa.

TELEMEDICINE BACKGROUND

Simply defined, telemedicine is medicine at a distance. The history of distant health care providers exchanging information about patient and topic oriented medical problems parallels the

history of medicine and technology. In the first half of this century, where telephone communications were unavailable or inadequate, medical radio networks were created to link onsite health care workers with urban medical centers. Health care providers in the Canadian northern territories and the Australian "outback" were early users of such networks. In the second half of the century, video image and fax transmissions greatly improved information transfer. Interactive video systems further increased the ability of remote consultants to guide clinical decision making in real time; the settings just cited were early beneficiaries of this expanded capability (2,3).

While didactic education has been (4-6) and remains (7,8) the most common medical use of video teleconferencing, the technology has been applied to clinical care activities in wide geographic distributions, varied practice settings, and many specialties (9,10). Concepts often were proved in urban environments: Teleradiology experiments began as early as 1950 (11). In 1964 in Nebraska, neuropsychiatric consultations were provided via two-way closed circuit television, demonstrating adequacy of transmission of neurological physical examinations and electroencephalograms (12). Beginning in 1967 in Boston, video mediated remote consultations in psychiatry, radiology, and dermatology were provided by physicians at Massachusetts General Hospital to employees and passengers at Logan Airport (13). Yet probably the most essential contributions of interactive telemedicine have been realized in clinical practice (14,15) and continuing medical education (16,17) in rural settings. The more remote and extreme environments particularly have benefitted (18-20).

Video mediated interactive consultations have been provided in anesthesiology (21,22), cardiopulmonary medicine (23), critical care (24), dental forensics (25), dermatology (13), emergency medicine (26,27), family practice (28), ophthalmology (29), and pediatrics (30). However, the specialties that stand out among early, frequent, and comprehensive providers of video mediated remote consultation are pathology (31,32), psychiatry (13,33,34), and radiology (35-37). Particularly within these last three specialties, remote diagnostic accuracy has been evaluated repeatedly (38-44) and found to be generally satisfactory. Although there are prior reports of the use of satellite mediated telecommunications for intercontinental clinical consultation (31) and international medical education (7), the Spacebridge project appears to represent the first use of interactive video telemedicine to provide remote multidisciplinary consultation to physicians in post disaster settings abroad.

TELEMEDICINE SPACEBRIDGE ORGANIZATION AND PROTOCOLS

In March 1989, representatives of the National Aeronautics and Space Administration (NASA) and four U.S. medical centers traveled to the U.S.S.R. In Armenia, visits to Spitak, the largest city near the earthquake epicenter, and the Republic Diagnostic Center in the capital city of

Yerevan, provided the Americans an opportunity to appreciate first hand the extent of destruction, understand the existing health care system, and meet Armenian physicians. In Moscow, meeting under the auspices of the U.S./U.S.S.R. Joint Working Group on Space Biology and Medicine, representatives of NASA and the U.S.S.R. Ministry of Health agreed to proceed with the Spacebridge project, and a general operations protocol was written. In April 1989, representatives of the Ministry of Health and the Republic Diagnostic Center visited NASA and the four U.S. medical centers, and a medical implementation plan was written.

The general operations protocol identified NASA Headquarters (Washington, DC) as the point of administrative coordination for U.S. activities, "Soyuzmedinform" of the Ministry of Health (Moscow) as the point of administrative coordination for Russian and Armenian activities, NASA Goddard Space Flight Center (Maryland) as the point of coordination for a satellite mediated telecommunications network, and the four U.S. medical centers shown in Table 1 (adjacent to their locations) as the primary sources of clinical consultation. The protocol specified two-way audio and fax and one-way video transmissions to link the Republic Diagnostic Center in Armenia to the four U.S. medical centers and NASA Headquarters until 1 July 1989. The Americans agreed to provide a portable satellite Earth station and video teleconferencing equipment, with "scrambled" signals to protect patient privacy. The Russians and Armenians assumed responsibility for language translation.

The medical implementation plan identified the categories of medical problems and topics for which the Armenians desired clinical consultation and medical education sessions, specified protocols for requesting and rendering consultations, and described protocols for radio transmission and use of language interpreters. The plan included a tentative 2-month schedule of operations with a nominal broadcast schedule of 4 hours daily (0900-1300 EDT; 1800-2200 in Yerevan), 5 days weekly. Clinical consultations and educational presentations were emphasized on Tuesdays-Thursdays; administrative planning and fax transmissions of patient data and medical literature were emphasized on Mondays and Fridays. (The voice terminating equipment of the communications system precluded simultaneous fax and voice transmissions.) Prescheduling the clinical problem areas and educational topics to be discussed permitted prospective designation of a "primary" and "secondary" U.S. medical center for each session, according to the expertise of centers (Table 1), availability of key specialists, and intent to maximize participation.

For each patient-specific clinical consultation desired, the Republic Diagnostic Center physician coordinator was expected to organize (and translate) the appropriate clinical information in a standard format and, on the Friday or Monday preceding the consultation session, transmit the information via fax to the U.S. medical center designated as "lead" for that session. Standard medical nomenclature and clinical laboratory units were agreed upon in advance. American consultants were encouraged to identify relevant medical journal articles and, on the Monday

TABLE 1. TELEMEDICINE SPACEBRIDGE PARTICIPANTS

<u>Telemedicine Spacebridge Centers</u>	<u>Institutions</u>	<u>Specialty emphases</u>	<u>Number of M.D. & Ph.D. participants</u>
ARMENIA:			
Yerevan	Republic Diagnostic Center	Tertiary care, diagnostic imaging, hyperbaric medicine	233
	Multiple Armenian hospitals	Multiple specialties and clinics	
RUSSIA:			
Ufa	Hospital 21	General hospital, burn care	14
UNITED STATES:			
Baltimore, Maryland	Maryland Institute for Emergency Medical Services Systems	Trauma, burns, critical care	18
Bethesda, Maryland	Uniformed Services University of the Health Sciences	Casualty management, psychiatry, epidemiology	64
	National Institutes of Health	Multidisciplinary tertiary care	
	National Naval Medical Center	Multidisciplinary tertiary care	
	Walter Reed Army Medical Center	Multidisciplinary tertiary care	
Houston, Texas	The University of Texas Health Science Center at Houston	Multidisciplinary tertiary care, trauma, burns, critical care	45
	The University of Texas M.D. Anderson Cancer Center	Oncology	
	Texas Institute for Rehabilitation Research	Rehabilitation medicine	
	U.S. Army Medical Center, Ft. Sam Houston, San Antonio	Burn care	
	Shriners Burn Institute, Galveston	Burn care	
Salt Lake City, Utah	LDS Hospital	Multidisciplinary tertiary care, trauma, critical care	45
	Primary Children's Hospital	Multidisciplinary pediatric care, pediatric trauma, critical care	
	University of Utah Medical Center	Multidisciplinary tertiary care, trauma, burns, critical care	
Washington DC	NASA Headquarters	Operational medicine, administration	3

preceding or the Friday following the consultation session, transmit the articles via fax to the Republic Diagnostic Center. It was understood that each Armenian physician presenting a patient and requesting consultation retained full responsibility as the physician managing that patient; American physicians rendering consultation functioned as consultants to the Armenian physicians, without direct responsibility for patient care.

SPACEBRIDGE OPERATIONS

The Spacebridge was operational almost daily, weekends and national holidays excepted, from 4 May to 28 July 1989. This was a month longer than originally planned: Following the gas explosion near Ufa, a mutual desire to utilize telemedicine consultation to aid management of the burn victims prompted extension of Spacebridge operations through July. As shown in Table 1, a total of 422 M.D.'s and Ph.D.'s and 34 communications specialists participated in the Spacebridge sessions. Among the Armenian physician participants, more than 60 were lecturers at the Yerevan Medical Institute of Advanced Physician Training, and 50 were directors of medical institutions.

As shown in Table 2, over the 12 weeks of Spacebridge operations, there were 34 clinically focused and 19 administratively oriented conferences, each of approximately 4 hours duration; 48 originated from the Republic Diagnostic Center in Yerevan; 5 originated from Hospital 21 in Ufa. Full motion color video was transmitted from Yerevan via Earth station satellite uplink; slow scan black and white video was sent from Ufa via land line to Yerevan, and thence via Earth station uplink. In one session, Salt Lake City and Yerevan were linked with two-way full motion color video. Only 2 of 55 intended broadcasts were canceled or deferred due to technical difficulties.

In Yerevan and Ufa, conference rooms were configured for video teleconferencing, with special attention to the demonstration of findings on physical and psychological examinations and diagnostic images. For some patients whose hospital status or outpatient location made it inconvenient or impossible to appear in real time, a video camcorder was used in Yerevan and a still camera was used in Ufa to prerecord salient points for replay during consultation sessions.

As Table 2 indicates, 209 individual patients were discussed. The 185 cases selected by the Armenians exhibited characteristics common to people seeking medical attention following a major disaster. The problems most frequently presented related to infectious disease, psychological decompensation, and surgical interventions. However, many of the most perplexing problems in these and other categories were endemic to the population or otherwise unrelated directly to the earthquake; after the earthquake, their management was compromised by other heavy demands on the crippled medical care system. Population subgroups that, due to local customs

TABLE 2. SUMMARY OF TELEMEDICINE SPACEBRIDGE CONFERENCES
AND IMPACT ON PATIENT MANAGEMENT

Clinical problem category introduced	No. of 4 hour conferences	No. of patient consults	No. of diagnoses altered	Interpretation of studies altered	New studies suggested	Diagnostic process altered	Treatment plan altered	New treatment method
Burn management	5	24					**	**
Burn wound care; nursing care	[3]							
Multiple trauma care	[1]							
Psychological support	[1]							
Endocrinology	1	5	1		2		2	2
Imaging	3	33	10	15	12	12		
Infectious disease:	5	15	2	2	7	5	4	1
Epidemiology and public health	[3]							
Specific disease management	[2]							
Internal medicine	1	5	1	1	2	2	2	
Laboratory diagnostics	1			4		5		
Neurology	1	5	1		2	2	3	1
Ophthalmology	1	6	2				1	1
Psychiatry and psychology	7	25	8		3		17	3
Renal failure and dialysis	1	6	1					
Surgery and trauma management:	6	44	21	2	30	16	12	5
Orthopedic reconstructive surgery, use of prosthetics, rehabilitation	[2]							
Plastic and reconstructive surgery, microvascular techniques	[1]							
Head and spinal injury, rehabilitation	[2]							
Neurosurgery (non traumatic)	[1]							
Urology	1	25			7	1	5	2
Vascular surgery	1	16	7	3	5	4	1	1
Clinical totals:	34	209	54	27	70	47	47**	16 **

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<u>Administrative category</u>								
Operations planning, interim critique	6							
Yerevan operations	[2]							
Ufa operations	[2]							
Overall operations; wrap up	[2]							
Disaster response organization	1							
Fax	12							
Administrative total:	19							
Total Spacebridge sessions:	53							

**** Note:** American burn treatment teams were present at Hospital 21 in Ufa within the second week after the gas explosion; this resulted in introduction of new burn treatment methods and significant changes in treatment plans, prior to Spacebridge consultation.

and ethnic conflicts, under-used the medical care system before the earthquake also were under-represented in their receipt of formal care after the disaster.

SUMMARY OF CONFERENCES AND CONSULTATIONS

Burn Management. Five conferences were devoted to management of major thermal injury. Three of these focused on early and late management of burn wounds. Among American burn specialists who had travelled to Ufa the previous month were surgeons and nurses from the Brooke Army Burn Unit in San Antonio and the Shriners Burns Institute in Galveston; they had provided onsite instruction, equipment, and supplies for early excision and grafting procedures. Several of these surgeons and nurses participated from Houston in Spacebridge conferences and thus were able to follow patient progress. Of the 104 burn victims received by Hospital 21 in Ufa, 24 remained hospitalized. With the aid of slow scan video images and exchange of specific questions and answers, the remote consultants were able to provide recommendations for further management of these patients. Skin grafting technique, use of antibiotics, parenteral and enteral nutrition, and nursing care were central issues. One conference was directed to management of concomitant injuries, including brain and eye trauma. Another session addressed psychological issues, including the increased stress on mass casualty care providers when the predominant injuries are severe burns, the impact of reduced support when mass casualties—particularly children—must be cared for at great distances from their homes, and the long term consequences of burns involving the face and hands.

Imaging. Paralleling previous telemedicine experiences, diagnostic images were among information most frequently discussed in the course of consultations for a broad spectrum of clinical problems. In addition, three conferences were devoted specifically to imaging techniques, choice of studies for particular problems, and interpretation of results. Beyond plain film radiography, there was emphasis on computed tomography (CT), ultrasound, doppler techniques, angiography, and nuclear scintigraphy. Image transmission was noted to be of high diagnostic quality; remote consultants were able to distinguish relatively subtle lesions in the brain, lung, liver, and pancreas. Of particular value to Armenian radiologists were discussions regarding use of contrast to enhance CT studies, and use of radioisotopes in nuclear medicine diagnostics.

Infectious Disease and Epidemiology. Public health in Armenia was a matter of grave concern because the earthquake had disrupted sanitation systems and forced relocation of thousands of survivors to temporary shelters. Therefore, one of the first conferences, attended by directors of the Republic of Armenia Epidemiological Service, was devoted to discussion of epidemiology and other public health issues. It was agreed that the communicable diseases most likely to be activated in large numbers after a disaster are those known to be endemic before the

disaster or those for which the causal agents have been identified. Thus reference to identified patterns of incidence and causes of infectious diseases prior to the earthquake offered the best guide to infection control solutions in the post disaster setting.

Specific diseases addressed were meningitis, upper respiratory infections, food poisoning, bacterial and amoebic dysentery, salmonellosis, viral enteritis with diarrhea, and viral hepatitis. Disruption of water supplies, food supplies, waste disposal systems, and prophylactic and therapeutic services were identified as major causal factors. Also contributory were the death of a large number of animals, and an increase in the population of rats and other rodents. The Armenians described measures already instituted on a broad scale; these included inhalation of gamma interferon to prevent upper respiratory infections, and bacteriophage treatment of intestinal infections. The role of antibiotics and immunization was addressed. Specific consultations for 15 patients were directed to differential diagnosis and management of meningitis, encephalitis, tuberculosis, hepatitis, herpes infection, and HIV infection.

Psychiatric and Psychological Rehabilitation. Seven conferences were devoted to discussion of the extensive psychiatric and psychological problems associated with major disasters. Topics included post-traumatic stress syndrome, major depressive reactions, the effects of loss of or separation from family members and homes, differential responses of young children and elderly adults, the impact of preexisting psychiatric disease and drug and alcohol abuse, the consequences of a major disaster on the mental health of the population at large, the ability of preexisting mental health services to respond to psychological decompensation following a major disaster, and the roles of pharmacotherapy, psychotherapy, psychoanalysis, group therapy, and outpatient care. To improve consultation effectiveness, the Uniformed Services University psychiatrists promptly communicated standardized approaches to psychiatric examination and diagnosis.

The psychological responses of several population subgroups received particular emphasis; these included children who had lost family members and homes, rescue workers who had encountered mangled bodies day after day, and medical personnel who had worked for extended intervals in the disaster zone. For the last group, work capacity and professional capability were of special interest.

Among the 25 patients presented, several demonstrated classical findings of post-traumatic stress disorder, major depression, and medication-induced toxic psychosis. Consistent with the previous observation that problems endemic to a population demand significant attention after a disaster, many of the cases involved situations that predated or otherwise were not related directly to the earthquake. A special example of this phenomenon was the psychological impact of repeated trauma: Some of the earthquake survivors previously had been involved in violent regional ethnic conflicts.

Pre- and post-disaster organization of mental health services was addressed, with emphasis upon ability to provide psychological and psychiatric aid to the population of a disaster zone. Prior to the earthquake, a comprehensive psychological service for the Republic of Armenia was still in the developmental stage; existing personnel and resources were incapable of coping with the impact of the earthquake on the mental health of the population. Hence a Republic Mental Health Center was established after the earthquake; the newly appointed director of that Center was one of the most active participants in the teleconferences. The final psychiatry and psychology conference included a review of the mental health care systems in both the U.S. and the U.S.S.R.

Renal Failure Management. Relative to many disaster settings, the Armenian earthquake produced a high incidence of renal failure among the injured. Many cases appeared related to crush syndrome, resulting in myoglobinuria, with inability to achieve timely expansion of vascular volume. Inability to initiate resuscitation promptly was a consequence of delayed rescue and delayed access to definitive treatment. Those delays, respectively, related to widespread destruction of the emergency services infrastructure and local medical care infrastructure.

Prior to the earthquake, there was a growing interest in hemodialysis in Armenia. New dialysis equipment, requiring shorter dialysis intervals and permitting treatment of more patients, had been provided as a component of international disaster response. A number of dialysis centers had been established; many specialists were engaged in training at these centers. A conference on renal failure management, at which six patients were presented, offered an opportunity for those physicians to ask questions of American colleagues experienced in dialysis and transplantation.

Surgery and Trauma Management. Many (in some towns, most) buildings collapsed in the Armenian earthquake, creating numerous casualties with crush injuries and polytrauma. At the time of Spacebridge operations, initial treatment of that population had been completed. The Armenian medical care system remained challenged, however, by a large number of patients with post trauma complications including chronic wounds, malunited fractures, and musculoskeletal and neurological functional deficits. As expected in the disaster recovery setting, discussion of trauma and other surgical problems (exclusive of burns) occupied the largest number of Spacebridge conferences (9), produced the largest number of patients presented for consultation (91), and involved the broadest spectrum of participating specialties (general surgery, neurosurgery, ophthalmology, organ transplantation, orthopedic surgery, pediatric surgery, plastic and reconstructive surgery, rehabilitation medicine).

Two conferences were directed to evaluation and management of musculoskeletal injuries, with emphasis on options for orthopedic and plastic surgical reconstruction, use of prosthetics, and the role of rehabilitation efforts. A separate conference focused on plastic and reconstructive surgery, with emphasis on microvascular surgical techniques and tissue transfer. Two conferences were devoted to evaluation and management of head and spinal injuries, with discussion of

paraplegia and quadriplegia, prevention and treatment of decubitus pressure ulcers, and the role of rehabilitation. These sessions were particularly valuable to several young specialists at the newly established Center for Spinal Rehabilitation in Yerevan. Separate conferences addressed evaluation and management of non traumatic central nervous system lesions and seizure disorders, eye injuries and diseases, genitourinary tract injuries and diseases including malignancies, and peripheral vascular disease. In this last session, intermittent claudication was a major issue and choice of vasodilation versus endarterectomy versus bypass grafting were central topics of discussion.

Recommendations for surgical treatment were based upon careful evaluation of patient status. Real time audio and full motion color video enabled consultants to request demonstration of and effectively observe location and character of wounds, motion and strength of limbs, and gait and neurological function. Thus remote consultants were able to guide examination and elicit specific findings. For several patients unable to appear in the conference room in Yerevan, a video camcorder was used to prerecord physical findings for later demonstration. For a pediatric orthopedic surgeon unable to be present in the conference room in Salt Lake City, a video recorder was used to record a patient's physical findings and diagnostic images for later review. In two cases involving musculoskeletal deformities—1 congenital, the other post traumatic, recommendations for complex orthopedic procedures led to referrals to the consulting surgeons who performed the operations *pro bono* in Salt Lake City and Houston.

Other Clinical Conferences. A conference was devoted to endocrinology, with discussion of five patients exhibiting difficult to manage problems including diabetic neuropathy and thyrotoxicosis. A separate conference on other internal medicine problems involved discussion of five patients with glomerulonephritis, osteogenesis imperfecta, systemic lupus erythematosus, fever of unknown origin, and Behcet's syndrome. A conference on laboratory diagnostics produced in depth discussion of the measurement and interpretation of immunologic, blood chemistry, and coagulation variables, and the role of laboratory studies in diagnosis of liver and pancreatic disease. Flow cytometry was a technique of particular interest to the Armenians. A conference devoted to neurology involved presentation of five patients, generating discussion of diagnosis and treatment of seizure disorders, use of evoked potentials, use of anticonvulsant medication during pregnancy, and management of multiple sclerosis.

Administrative Conferences. Two conferences were used to critique and revise Yerevan operations, 2 conferences were used to plan the urgent transition to operations in Ufa, 1 conference reviewed disaster management organization, 2 conferences were devoted to a final critique of operations and closing ceremonies, and 12 sessions were devoted largely to fax transmissions. Early in the course of Spacebridge operations, two facts were recognized: First, priorities of patient problems and availabilities of key physicians changed frequently. Second, for the U.S.

medical centers, Spacebridge transmissions were the only practical means by which to communicate with Armenia (establishing telephone contact required hours; mail delivery requires weeks to months) and the most convenient means by which to communicate with each other. Thus it was necessary at intervals to revise conference topics and reschedule participants; satellite mediated dialogue between centers helped to effect the changes promptly and accurately.

EVALUATIONS OF SPACEBRIDGE CONSULTATIONS

Armenian Physician Evaluation. The physician coordinators of the Spacebridge project at the Republic Diagnostic Center in Yerevan, Doctors Haik Nikogossian and Ashot Sarkisian, recorded the changes in patient evaluation and management which occurred as a result of telemedicine consultations. The results of this evaluation are shown in Table 2. Significantly, diagnoses were altered for 54, new diagnostic studies were recommended for 70, diagnostic process was altered for 47, and treatment plans were altered for 47 of the 185 Armenian patients presented. Within the surgical subgroup, the impact was even more dramatic: Diagnoses were altered for almost half, additional studies were recommended for almost three quarters, and treatment plans were modified for more than one-quarter of the 44 patients discussed.

American Physician Evaluation. Subsequent to rendering consultations, American physicians were asked to evaluate Spacebridge operations. The issues addressed and the responses obtained are summarized in Table 3. Early in the course of telemedicine operations it was evident that quality of consultation depended directly upon prior knowledge of cases to be presented and questions to be asked. The quality with which diagnostic images were transmitted using standard video equipment was a pleasant surprise.

DISCUSSION

Initiation of Operations Relative to Disaster Occurrence. While Spacebridge operations were timely relative to the Ufa train disaster, the project clearly represented a late phase response relative to the Armenian earthquake. By mid December 1988, within a week after the earthquake, it had been determined that clinical faculties of the U.S. medical centers, the telecommunications units of these institutions, and the telecommunications center at NASA Goddard were willing and ready to participate. However, negotiations at higher levels of government to achieve the necessary bilateral international agreements were not completed until April 1990. This experience parallels that of other international response teams lacking contingency agreements prior to a disaster.

**TABLE 3. CLINICAL AND TECHNICAL QUALITY OF SPACEBRIDGE CONSULTATIONS:
AMERICAN PHYSICIAN EVALUATION**

<u>Issue</u>	<u>Consensus</u>
Adequacy of clinical background information	More than adequate, when provided in advance via fax. In several cases, absence of relevant information in advance resulted in unavailability of the appropriate specialty expert during the consultation session.
Adequacy of laboratory and imaging studies	Generally comparable to U.S. medical centers, particularly with addition of certain techniques common to U.S. practice (e.g., greater use of contrast to enhance CT imaging).
Accuracy and effectiveness of language translation	Excellent.
Diagnostic quality of audio transmission	Excellent.
Diagnostic quality of video transmission	Full motion color video quality was excellent. The clarity of transmission of diagnostic images using standard video equipment exceeded expectations. Black and white slow scan video quality was adequate for images. It sometimes was inadequate for evaluation of the extent and severity of burn injury.
Accuracy and appropriateness of consultations	Consultations were perceived to be highly accurate and appropriate.
Comfort and confidence in providing consultation in this format	A high degree of comfort and confidence was expressed.
Acquisition of information professionally useful to consultant	Most consultants felt they gained from the experience.
Willingness to participate in similar telemedicine projects in the future:	Almost all consultants expressed a desire to be involved in similar projects in the future.

An additional minor delay was incurred waiting for an Aeroflot aircraft of sufficient size to transport a large van-mounted satellite Earth station from Houston to Yerevan. Subsequent inability to move the van conveniently and rapidly from Yerevan to Ufa resulted in the absence of full motion color video during Ufa operations.

Language Translation. An initial concern was potential compromise of consultation effectiveness due to inaccurate or inefficient language translation, differences in medical technology and nomenclature, and influence of cultural differences. With rare exception, the effects were negligible. The translation skills of the Armenians and Russians were excellent.

Participation of Several Medical Centers. With simultaneous telemedicine consultation from several medical centers, there were concerns about potential difficulty coordinating sequential input from remote consultants unable to see each other or read each other's "body language," and conference disharmony or primary physician confusion created by forceful expression of conflicting clinical opinions. Fortunately, these problems were not encountered. Instead, concurrent participation repeatedly assured cross coverage when specific expertise was absent in the conference room at the "lead" center. More importantly, from the consultants' point of view, clinical problem solving interaction with colleagues at other institutions was one of the most enjoyable aspects of the Spacebridge. For example, following transmission of a challenging question from an Armenian physician, a typical "off line" comment in Houston was "I hope Utah will take that one first," or "I wonder what Maryland will say about that"; following transmission of an answer, a typical off line comment was "I wonder if Utah and Maryland will agree with that." The learning process clearly was multidirectional and collegial. When Spacebridge ended, some consultants expressed feeling a loss of valuable contact.

Participation of Physicians. As noted, quality of consultation related directly to presence and preparation of the consultants. Consistent presence of the right people with the right information at the right time required at least two things: First, it was necessary for primary physicians to identify patients, topics, and questions with sufficient lead time for coordinators to schedule appropriate specialists to be present (or alternatively, it was necessary to know where the experts were scheduled to be so that questions could be directed to them at that place and time). Second, once an expert was present in the conference room, it was important that specialty specific problems be presented promptly, before the consultant was called away to do something else or departed because of disinterest.

The most productive clinical consultation sessions were those for which these principles were followed. Conversely, the least productive sessions were those for which patients had not been identified or information and specific questions had not been transmitted in advance, or new patients or new questions were introduced ad hoc during the session. For example, body CT radiologists were reluctant to answer questions regarding head CT findings; they wished to defer

those questions to a neuroradiologist. When questions regarding therapeutic intervention were mixed with discussion of imaging, the radiologist wished to defer to the appropriate surgeon (e.g., a neurosurgeon). Once present, these specialists became anxious to leave when unrelated topics were discussed.

Another failure mode for clinical conferences was deviation from case discussion to lecture oriented format. Consultants' interest was captured and maintained by concise presentation and focused discussion of specific patient problems; conversely, interest waned when Armenian physicians or U.S. consultants drifted into speeches or lengthy tangential analyses. Consultations of a truly emergent nature often were among the most successful, despite minimum time for preparation. Requests for those consultations usually were accompanied by specific information and questions, permitting identification and preparation of the appropriate consultants even on short notice; discussions of such cases usually remained well focused on relevant clinical issues.

As with face to face consultation, periodic failure to bring key studies (e.g., radiographs) to the conference room reduced success. In Spacebridge operations, it often was inconvenient or impossible to present such data to the appropriate consultant at a later date.

Ability to Convey Ideas Graphically. The ability to convey ideas graphically in real time has been found to be important in other applications of teleconferencing. Indeed, a number of times in Spacebridge operations, remote consultants wished to point to an anatomic finding on a patient, demonstrate (rather than describe) a physical examination maneuver, point to a detail on a diagnostic image, diagram a reconstructive surgical procedure being considered, or point to details in a journal article. This was impossible or inconvenient because video transmission was not two-way, the system was not equipped with an electronic pointer or pen, and fax transmission required interruption of the conference dialogue.

It was necessary to dedicate significant time to fax transmissions for several reasons. Quality of consultations related directly to availability of written patient information in advance. Because many medical journals are not conveniently available in Armenia and Russia, providing copies of (rather than referencing) selected journal articles was the most effective means for consultants to augment information they wished to convey. Fax was the only practical means by which to exchange written and graphic information in a timely manner. Hundreds of pages of patient information and over a thousand pages of journal articles were exchanged. As previously noted, the communications system did not permit simultaneous fax and voice transmissions.

Physicians and patients in Armenia repeatedly expressed a desire to see the American physicians providing consultation. Since this was precluded by absence of two-way video link, the Armenians requested photographs of the consultants and openly referred to them during consultations.

CONCLUSIONS AND RECOMMENDATIONS

Telemedicine and International Disaster Response

The Spacebridge project demonstrated that interactive consultation by remote medical specialists, via satellite mediated telecommunications on an international scale, can provide valuable assistance to onsite physicians in the aftermath of major disasters. Telemedicine can bring to physicians working in a distant disaster zone the expertise of scores of top specialists who simply cannot all travel to the site in person. This assistance can favorably impact clinical decision making in the late phase of post disaster medical response.

For the future, an important question is: How soon after a major disaster may telemedicine consultation be of benefit? A possible first impression is that remote consultation can be of little or no value until the inevitable confusion associated with the first few days has been resolved. However, this impression appears to conflict with several accepted principles of trauma management and specialty consultation: For major trauma, initial evaluation and management often determine final outcome. In mass casualty situations, triage often is performed in forward locations by senior surgeons, in order to maximize accuracy of initial decisions. For complicated clinical problems, the earlier an appropriate specialist is consulted, the more likely it is that complications can be prevented or minimized. Therefore, appropriately planned and organized, it is anticipated that telemedicine consultation by selected specialty experts will more favorably impact process and outcome if provided relatively early in the post disaster interval. In addition to providing access to remote specialty expertise, early telemedicine communications may assist in-country teams of external responders by providing information to guide optimum deployment of their resources.

Several steps can be taken to enhance opportunity to provide effective telemedicine assistance in the early post disaster interval: To reduce delays related to government negotiations, international agreements for entry and operation of telecommunications equipment should be in place prior to a disaster. To reduce delays related to assembly or transport of telemedicine communications equipment, modular portable telecommunications units, capable of transport on commercial aircraft, should be available pre disaster. To reduce failures related to equipment reliability and consultant availability, telecommunications equipment and medical specialists should be engaged in telemedicine operations, domestically or internationally, on a routine basis.

Interaction with Onsite Physicians. Following most major disasters, the majority of medical care will be provided by local physicians and health care workers rather than external disaster response teams who travel to the site. Therefore, the prior training and organization of local medical professionals, and the ability of external consultants to interact smoothly with local physicians, are major determinants of the outcome of national and international disaster response

efforts. Language barriers, differences in medical technology and terminology, and cultural differences may limit success of international telemedicine operations; agreements regarding language translation protocols and medical terminology standards may reduce that impact. The high quality and professionalism of the Armenian physicians and the excellent translation abilities of the Russians were major contributors to the immediate success of the Spacebridge.

In the longer term, if the development and orientation of a local health care system permit the medical information base to be enhanced by remote consultation and education, then telemedicine interactions can favorably impact regional health care for years after a disaster response. That appears to be the case in Armenia and Ufa.

Selection and Participation of Remote Consultants. To provide telemedicine assistance to a major disaster zone where there exist a broad spectrum of health care demands and a disrupted health care infrastructure, concurrent participation of several remote consultation centers may be beneficial. To coordinate communications requests and operations, an "action center" may be helpful; this may be located at one of the participating medical centers, or elsewhere.

Quality of consultation depends upon timely presence of appropriate consultants prepared with the appropriate information. In turn, for nonemergent cases, availability and preparation of consultants depends upon foreknowledge of patients to be presented and questions to be asked. Thus for scheduled consultations, information should be transmitted in a standard format with sufficient lead time to permit optimum consultant selection and preparation.

Frequent changes in priorities of patient problems and availabilities of key physicians represent the rule rather than the exception. Flexibility to revise topics and reschedule consultants promptly and accurately is critical to clinical success.

Maximum value from consultation sessions is derived from concise presentation and focused discussion of specific patient problems, avoiding lengthy lectures and tangential analyses. When a number of patients are presented or several specialty areas are discussed, use of consultants' time is optimized by identification, in advance, of the order in which specific areas will be discussed and how much time will be devoted to each. Once present, a consultant's expertise should be "used" promptly, before the expert is called away or loses interest.

Telemedicine Communications Systems. For interactive medical consultation, bidirectional audio is essential, unidirectional video is adequate, and bidirectional motion color video is desirable. Bidirectional video is desired to permit primary physicians and patients to see their consultants, and allow consultants to demonstrate as well as describe certain maneuvers and procedures. Motion video is desired to allow evaluation of musculoskeletal, neurological, and psychological performance. Color video is desired to permit appreciation of subtle features of wounds and skin lesions. During many consultations, the ability to convey ideas graphically in real time is desired; therefore, telemedicine systems should incorporate the electronic pointer and

pen components that are available in several teleconferencing systems. Fax is a valuable means by which to exchange information before, during, and after consultation. It is important to be able to fax without interrupting dialogue. At appropriate transmission rates, digital compression technology may combine the convenience of digital data storage and recall with the advantages of motion video just cited. For disaster response teams that travel to provide care in-country, a modular portable critical care workstation with computer assisted data acquisition and interpretation may provide a convenient "front end" interface to telemedicine systems.

Future Directions. A Telemedicine Implementation Team was defined at the conclusion of the Spacebridge project, with the intent to incorporate many of the foregoing recommendations and features in a follow-on demonstration project. In early disaster response efforts, telemedicine should attempt to complement and assist—not substitute for—external teams who travel to provide care onsite. Interface with rapid response teams, such as those recently organized and equipped by the Society of Critical Care Medicine, should be a primary goal of future global telemedicine efforts.

Global telemedicine may play an important role preceding as well as following disasters. Ability of the international medical community to respond to acute major disasters should be enhanced by the permanent presence of a world-wide medical telecommunications network that is able to track endemic infections and "ongoing disasters" (e.g., cholera and yellow fever in South America, HIV in Central Africa), monitor the capabilities and limitations of medical care infrastructures within many countries, and promptly and accurately report early damage following sudden catastrophes.

Extraterrestrial telemedicine capability will be key to achieving the goal of expanded human presence in the solar system. Timely reliable access to remote medical specialty consultation will be a central feature of the health care systems of space stations, lunar bases, and Mars missions. A global medical telecommunications network will be required to facilitate effective multinational responses to catastrophes in extraterrestrial settings. As with other medical devices and techniques, spaceflight telemedicine systems will require critical evaluation with real patients in order to be considered qualified. Thus the space programs of the U.S., Russia, and other nations have vested interests in the development and validation of telemedicine systems.

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Use of Telescience for Biomedical Research During Space Flight

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When the U.S. first embarked on a manned space flight program, NASA's use of medical telescience was focused on crew health monitoring. In recent years, medical telescience use has been expanded to include support of basic research in space medicine. It enables ground support personnel to assist on-board crews in the performance of experiments and improves the quality and quantity of data return. NASA is continuing to develop its telescience capabilities. Future plans include telemedicine that will enable physicians on Earth to support crewmembers during flight and telescience that will enable investigators at their home institutions to support and conduct in-flight medical research. This paper describes NASA's use of telescience for crew safety and biomedical research from Project Mercury to the present and presents NASA's plans for the future.

For the Mercury, Gemini, Apollo, and Skylab programs, air to ground and ground to air transmissions were relayed by the Manned Space Flight Network, a world-wide network of ground tracking stations. Modifications and augmentations were made to the Network for each successive program to provide increased data handling. For the Mercury and Gemini Programs, two-way audio and data transmission were possible. The capability to downlink video images was added for the Apollo and Skylab Programs. Transmissions from or to a spacecraft were possible only when the spacecraft was over one of the tracking stations. At these times both real-time data and data previously recorded on-board were downlinked.

All four programs conducted in-flight medical monitoring. Physicians and support-personnel provided continuous monitoring from the ground. During Mercury and Gemini they relied on voice communications and biotelemetry. Electrocardiogram (ECG), blood pressure, respiration rate and body temperature data were continuously monitored. For Apollo, video monitoring and metabolic expenditure monitoring during extravehicular activity (EVA) were

added. (An approximate measure of metabolic expenditure was calculated by monitoring oxygen usage and the inlet and the outlet temperatures of the liquid-cooled garment.) During Skylab, physiological measurements were made during launch, docking, EVA, landing, medical experiment performance and medical emergencies as needed.

The use of telemedicine for medical investigations also increased from the Mercury to Skylab Program. Prior to Skylab, audio communications between the ground and crews were used as required but data collected from in-flight medical investigations were not downlinked. During Mercury and Apollo, no extensive in-flight medical investigations were conducted. On Apollo 16 and 17, urine samples were collected for endocrine, metabolic, and clinical biochemistry studies, and deviations from programmed menus were reported for nutritional studies. Several in-flight medical investigations were performed during Gemini 4, 5, and 7, including studies to evaluate depth of sleep, human otolith function, and duration of the cardiac cycle and its phases. Data from these investigations were recorded, and investigators obtained their data postflight. During the Skylab Program numerous in-flight medical investigations were performed and experiment data were downlinked. The Lower Body Negative Pressure device was used to test orthostatic tolerance. Other studies included venous compliance measurements and testing of vestibular function. The majority of experiment data were recorded on-board and downlinked later, with investigators receiving complete experiment data within 12 to 24 hours after completion of an experiment. Experiments were discussed by the crew and investigators on a weekly basis, providing the investigators an opportunity to modify protocols based on the data gathered and downlinked.

Presently, the Tracking and Data Relay Satellite System (TDRSS) is used to relay transmissions from the Space Shuttle to the ground and the ground to the shuttle. Telecommunications consist of two-way audio and data transmission, and video downlink. Both dedicated-experiment video and general video of crew activities can be downlinked. Real-time communication can be accomplished during periods when the Orbiter's Ku-band or one of the four S-band antennas has a direct line of sight to one of the TDRSS satellites. (Ku-band is used for high data rate, voice and video transmissions, and S-band is used for voice and low data rate transmissions.) These periods vary depending on the Orbiter's attitude. During periods when real-time communication is lost, data is recorded on-board and later downlinked.

To support crew health and safety, continuous indirect monitoring and periodic direct monitoring of every flight crew is conducted by a Flight Surgeon who is located either at the Mission Control Center or the Science Monitoring Area (SMA). Indirect monitoring involves monitoring video and voice transmissions. Direct monitoring involves conducting Private Medical Conferences (PMCs) and monitoring downlinked biomedical data. During PMCs medical concerns or treatments are discussed with the crew and, if required, ECG data can be downlinked for the Flight Surgeon to monitor. These conferences are scheduled each day and additional conferences can be conducted if requested. During EVA and medical investigations

biomedical data is downlinked for the Flight Surgeon to monitor. Data downlinked during EVA include EVA suit pressure, the partial pressure of carbon dioxide, the amount of oxygen remaining, and the EVA crewmembers' ECG data. During medical investigations, physiological data is monitored to verify the health of the crewmembers performing the investigation. If a crewmember's health is in jeopardy, the investigation may be interrupted by the Flight Surgeon. For example, throughout the performance of the Lower Body Negative Pressure investigation on STS-32, the Flight Surgeon monitored the subject's ECG and blood pressure. No complications arose during the performance of the experiment.

Telescience is used to involve ground-based researchers and support personnel in biomedical research being conducted on the Space Shuttle, thereby providing maximum scientific return. During a mission, investigators located at an investigator monitoring area monitor and review processed downlinked data and can communicate with the crew when necessary to assure proper conduct of their experiments. The SMA at the Johnson Space Center is primarily used by investigators to monitor experiments involving human subjects while the Test Monitoring Area (TMA) at the Ames Research Center is used to monitor experiments involving animal subjects.

Investigators are responsible for observing in-flight activities, monitoring experiment data, and adjusting experiment protocols. By observing televised activities of crewmembers performing experiments, investigators can verify that procedures are performed correctly, record any factors affecting their data, and verify the time of experiment performance. Monitoring experiment data in real time or close to real time, allows investigators to verify the quality of the data and hardware performance. Observing experiment performance, discussing it with the crew, and monitoring downlinked data, allows investigators to adjust experiment protocols or develop alternate procedures if necessary.

For Spacelab missions, additional monitoring is performed from the Payload Operations Control Center (POCC) at the Marshall Space Flight Center. From the POCC the performance of the entire payload is overseen. Ground-support personnel provide 24-hour support to insure overall mission success. Their responsibilities include recording data and playing it back, monitoring experiment hardware, and revising the daily timeline when necessary. Data are acquired and recorded during Acquisition of Signal and can be played back for review. Experiment hardware is monitored to verify performance and identify hardware malfunctions to minimize science loss. In the event of a malfunction, ground-support personnel will instruct the crew to initiate malfunction procedures or use backup hardware, or they will develop alternate protocols for the crew. They also provide re-plan capability if the daily timeline needs to be revised based on experiment performance.

To illustrate NASA's use of telescience, examples of its use during the recent Spacelab Life Sciences 1 (SLS-1) mission, during which extensive biomedical research was conducted, are presented. SLS-1, launched on June 5, 1991, was the first life sciences dedicated Spacelab

mission. Its payload was composed of investigations of the mechanisms, magnitudes, and time course of physiological changes due to space flight and investigations of the consequences of the body's adaptation to weightlessness and readjustment to 1-g. SLS-1 was a nine-day mission and had a crew of seven, four payload crewmembers and three Orbiter crewmembers. In addition, the experiment investigators and ground-support personnel were also involved in the collection of in-flight medical experiment data.

Remote hardware monitoring was one area on SLS-1 in which telescience support was provided by ground-based personnel. For example, rising refrigerator and freezer temperatures were detected and closely monitored by ground-support personnel during the mission. When temperatures rose above specification, ground-support personnel developed several solutions to avoid the loss of experiment samples. Ground-support personnel also monitored the Research Animal Holding Facility's environmental parameters, conserving crew time during the day and allowing monitoring while the crew slept. If required, the ground also had the capability to remotely control alarm sensor limits.

Video monitoring was another use of telescience during SLS-1. It allowed, in combination with crew comments, ground-support personnel to verify the operation of the General Purpose Work Station, thereby permitting animal handling by crewmembers. It also allowed investigators to view echocardiography data and verify its quality.

Also utilized on SLS-1 was the investigators' capability to monitor downlinked data. For example, investigators detected noise in the data being downlinked from the Gas Analyzer Mass Spectrometer during an investigation and alerted ground-support personnel to the problem. The ground-support personnel were able to develop and uplink a solution for crew implementation. The result of implementing the procedures developed on the ground was improved data quality.

For upcoming Spacelab missions NASA will expand its telescience capability by providing investigators the same data-monitoring capability they now have at the SMA and TMA at other locations. Remote Data Acquisition and Analyses Equipment, developed as a derivative of telescience research for Space Station Freedom, will be used by investigators for data acquisition. (The system consists of a workstation linked through a computer network to a data-monitoring area.) During the Spacelab Japanese mission, the Remote Data Acquisition and Analyses Equipment will be used as the backup monitoring system for investigators at the Marshall Space Flight Center. During the Spacelab Deutsche 2 mission, it will be the primary monitoring system for investigators in Germany. There is also a potential for its use during preflight and postflight data collection.

In the future, NASA plans to expand its use of both telemedicine and telescience. For the Space Station Freedom, NASA's primary goal for telemedicine is to give physicians the ability to provide remote health care support to the on-board Crew Medical Officer (CMO). Ground-based physicians will provide telemedicine support from the Space Station Control Center.

Aboard the station, the Health Maintenance Facility (HMF) will provide the medical equipment for the CMO.

When the space station is completed, telemedicine capabilities will include two-way audio communication between the physician and crew, downlink and on-board display of radiographic and non-radiographic images, and transmission of data from on-board medical hardware. Radiography of the face and mandible, skull, neck, spine, chest, abdomen, gall bladder, extremities, peripheral soft tissues, pelvis and urinary tract will be possible. Non-Radiographic imaging will include both macroscopic and microscopic imaging. Fixed and portable video cameras will acquire and transmit full color, full motion video images of physical examinations in space of various medical, surgical, and dental procedures. A microscope video camera will transmit a microscopic image to the ground for diagnosis by an expert observer. It will capture a color video image of the microscope's visual field for downlink. Physiological data such as ECG, blood pressure, and pulse oximetry will also be downlinked.

An example of HMF hardware that will provide telemedicine support is the Electronic Stethoscope System. It will be used to downlink the audio auscultation portion of physical examinations. The Stethoscope acquires, stores, replays, and transmits auscultated sounds of the heart, lungs, and bowels. The system has already been tested with positive results. A signal was transmitted from a mock-up of the HMF to physicians at a remote workstation, where they gave a positive clinical evaluation of the system.

NASA's primary goals for telescience for the space station are to permit investigators access to payload data, in real-time, from any network location and to allow investigators control of on-orbit experiments. Requirements for meeting these goals include a communications network for real-time audio, video, and data transmission. Data to be transmitted will include experiment hardware parameters, station environmental parameters, experiment data, science data, and experiment execution commands. The benefits of the use of telescience for Space Station Freedom research include reduced crew time requirements, the ability for investigators to access supporting data through the network, the provision of data distribution services through the network, and an overall increase in science productivity.

In summary, telescience and telemedicine technology has evolved as NASA's space program has evolved. From the Mercury to the Apollo Program, communications and medical telemetry was used for in-flight crew health monitoring. For the Skylab Program, the addition of near real-time downlink of science investigation data was added for additional crew health monitoring and for support of medical investigations. Presently in the Space Shuttle Program, science investigation data can be downlinked in real-time. For the future, NASA is continuing research and development of telemedicine and telescience technology for Space Station Freedom. Telemedicine has been an important tool for safeguarding the health of astronauts and ensuring the success of in-flight experiments, and it will be indispensable for the long-term sojourns in space that will come in the future.

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Global Considerations for Implementation of Telemedicine

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In December 1989, the United Nations proclaimed the Decade 1990-1999 as the "International Decade for Natural Disasters Reduction" (IDNDR).

As stated in the report, "The Decade is an opportunity for the world community, in a spirit of global cooperation, to use the considerable existing scientific and technical knowledge to alleviate human suffering and enhance economic security."

Which scientific and which technical knowledge? I quote from the Report of the Group of Experts: "New instruments and enlarged networks collect more and better data. There are opportunities in the Decade for extension and integration of existing databases using advanced computer technology. Another important breakthrough has been data gathering by satellites, readily providing information globally."

Indeed, the Decade identified a number of research programs, proposed by the UN and its specialized agencies, including the World Health Organization and its Regional Office for the Americas, the Pan American Health Organization (PAHO), by the International Council of Scientific Unions (ICSU), and by other bodies. Computer applications and communications, including teledetection, constitute a significant part of these projects.

As health professionals, our specific aim in disasters is to reduce deaths, casualties, and long-term adverse health effects. Where, how, and under what conditions could these new technologies be applied in the health field?

To get a clearer picture, disasters may be viewed as a system arbitrarily divided in five phases. It is the so-called "integrated approach"—central to the decade, a reductionist view—that makes disasters treatable as a system.

1. The anticipative phase. That is the dormant period in a disaster-prone area. It is the time for pre-disaster planning, including prevention, mitigation and preparedness.
2. The pre-disaster phase. This is the time for warning.
3. The impact phase. There is chaos, death, and shambles. The stricken community is isolated from the rest of the world. It is the time for rescue.
4. The relief phase. Feedback information is required for the organization and coordination of external assistance.

5. The rehabilitation phase. It is the time to learn from the past in order to get better prepared.

New technologies are useful at all these stages, although their relevance may vary according to the type of disasters. In the anticipative phase: remote-sensing and satellite imagery for land use planning, monitoring of drought and crops, hazard mapping, identification of secondary hazards, modelling for forest fires or spread of floods, simulation exercises for decision-making and preparedness of the public, computer databases of resources and expertise. Before an impending disaster: tracking of cyclones, monitoring of floods and volcanic eruptions, early warning for storms. In the relief and rescue phases: communications for search and rescue, surveys of destroyed areas, assessment of damages, monitoring of external assistance.

Communication of the right information at the right time and to the right place is an essential requirement of the health management for disasters. The fusion of computer science and new communication technologies makes possible the instant delivery of a huge amount of information aggregated from multiple and distant sources. This instantaneity is a major asset for disaster management when rapid decision is often a critical factor. The issue is how to develop the existing technologies into useful applications in the context of disasters. The information must be relevant, organized, geared to decision-making, and applicable in disaster-prone countries, which, for a large part, are poor countries.

A great future is opening up, but there are also a number of caveats.

1. Gadgetry. Often techniques are developed primarily to respond to an intellectual challenge rather than to serve a specific human need. Practical applications of technological breakthroughs take time to ripen. It is like evolution—mutation first, with all kinds of tentative, hybrid creatures. Selection comes later. Emergent techniques are for a while like actors in search of a play. Today the major outlet of integrated circuits, the most voracious chipsphages so to speak, are computer games. It is the time for gadgetry, which makes for irrelevance. The stage where at the moment sensors, satellites, computer networks, megabytes storage, optic fibers act out their play is still set in a scenery of prestige, vested interests, and at times futility.

New technologies should be used whenever and wherever they may provide relevant information. That information should be meaningful and cost acceptable.

It should also be integrated with commonplace and more prosaic methods. For example, while remote sensing systems are of growing importance in planning for disasters, they should be complementary to ground surveys, which can provide data not obtainable from satellites. Newspaper clips, rumors, snake behavior, and tam-tams are also part of information. There should be no technological dogmatism in that matter. There is indeed an educational value in this blending of the new and the old. Comparisons of space and ground observations, by a better visualization of the mechanisms involved, may also enhance public awareness and preparedness

for disasters. One has to remember how weather forecasts with maps from satellites have introduced meteorology to the living room.

The conquest of relevance in the collection, transmission, and presentation of information calls for a dialogue between disaster managers and information specialists. Managers should know the opportunities as well as the limits of the emerging technologies. They should be involved in the design of new systems and their testing.

2. Language. Irrelevance may also proceed from the illusion that computers can generate meaningful information from unstructured and sloppy data.

As a first rule, terms have to be defined, categorized, and standardized. For example, epidemiological surveillance or post-disaster surveys require a precise definition of what is meant by death from impact, casualty, hospitalization, medical care, evacuation, psychological trauma, and similar terms. It is urgent to refrain from embarking on projects of large databases if there is no standard language agreed upon in advance. This requirement also has an educational value, since it will oblige the users to clearly formulate their objectives and to adhere to strict protocols.

Health professionals for their part have to learn how to think dichotomously, in bits. Before juggling with computers, they need to learn how to talk to computers. Before dreaming of entering hodgepodge data on terminals, they need to wire their own diagnostic mental networks. The inventory of useful decision-making data, its organization in significant algorithms, and the definition of format for presentation is the first priority.

3. Probabilities. Disaster management is for a large part made of decisions under conditions of uncertainty. Prevention is game theory, gambling on calculated risks. Prediction is betting. Evaluation of radiation accidents is balancing individual vs. collective, stochastic vs. non-stochastic risks. Human beings do not like probabilities. While they are quite apt to grasp odds ratios when betting on horses, they are reluctant to accept risks in real life. They want certainty, no false positives and false negatives. To top it all, zero risk is the motto. No cancer risk at any dose whatsoever, wherever, whenever, as exemplified in the Delaney Amendment.

When it goes to policy-makers, it gets worse. Dilemma is their best recipe for panic. At what moment should they issue warnings, either early, being sensitive at the risk of crying wolf and losing credibility at the next turn, or to be specific, being late and too late perhaps.

Continuous on-line telemonitoring raises another problem. Let us take as an example the monitoring of physiological parameters in individual persons through all kinds of sensors. People can be followed and watched for any irregularity in their heartbeat, blood sugar, brain waves, blood pressure, wherever they go or whatever they do, working, jogging, loving, movie-watching, scuba diving. What is a normal value? And when to give an alarm? Unless in exceptional situations such as for astronauts or for patients under intensive care, variations of physiological parameters on a continuous basis are much less well understood than the seismicity

of the earth's crust. Repetitive medical examinations and multipurpose health screening are also known to generate anxiety. Electronic devices for preventing sudden infant death—cot death—sound so many repetitive false alarms that the parents either disconnect them or end up at the psychiatrist. A number of health problems are medically engineered.

People also confuse relative risks, that is, the risks in individuals, and attributable risks, i.e., the risks in populations. A small relative excess risk in many people may be more important than a large risk in a few people. Following Chernobyl, it has been guesstimated that up to 100,000 women in Western Europe had a pregnancy terminated, although the relative risk of a malformed baby was insignificant. Indeed, in our EUROCAT study, which monitors some 350,000 births per year in the countries of the European Community, no excess risk of a malformed baby was detected in the months following the Chernobyl accident.

People also confuse risk and detriment. Technology and better safety control can decrease the risks while they increase the detriment should a disaster occur.

Archaic or primitive societies were at ease with chance events. Outcomes were blamed on gods or devils. By contrast, the concept of probabilities is still quite unfamiliar to modern man. Hence, possibly, the success of horoscopes, the fascination with parapsychology, and the blooming of sects.

Prevention of disasters, prediction, warning, appropriate preparedness of the public, assessment of damages, surveillance of the long-term effects, will be effective only if people understand more about the vagaries of chance outcomes. The media could here play a major role in making probability a household concept.

4. Decision. Information for the sake of information is worthless. Information should serve decision. It should be timely and accurate. New computer and communication technologies make it possible to provide information integrated from a multiplicity of sources. But what information, how collected, and to do what?

The future no doubt holds great promise. The constraints of time and space will have been abolished. Sensors will be ubiquitous, everything will be networked and linked with anything. People on the move, refugees or evacuees, will be followed like polar bears or salmon. Satellites will zoom in from space on details on the earth. Computer modelling and simulation will probe the future, reconstitute the past, and experiment with a universe of imaginary disaster situations, blurring boundaries between the actual and the virtual world. Databases will regurgitate all the information ever secreted by mankind, with the exception of graffiti (computers will generate their own graffiti known as worms and viruses). Infojunk and rotten data will pervasively make their way into the system, like fax advertising today.

Versey and Afonte at a recent Annenberg Conference raised the question that while "computerized technology can absorb masses of information and disgorge it on command, ... can

emergency managers deal with this information onslaught?" How will decisions be taken in confronting such a deluge of unfiltered, non-hierarchized, haphazardly presented information? At the information supermarket, too many choices means no choice. One is tempted to call here on the concepts of self-criticality and chaos—which are à la mode. The final menu presented to the decision maker could be an apocalyptic Mandelbrot set.

This is not a doomsday vision of the future. Communications and computer networks are today still a cottage industry and applications will turn up. Some of the problems will vanish. Society will settle into a new information ecology.

Yet the challenge is to make the best possible use of these opening-up technologies in order to improve present day disaster management while being on the move to look for future useful applications.

How to define, how to filter, how to organize, how to present the increasing amount of information? Selection of information, that is where real thinking is required. There is a need for some coordinating superclearinghouse to tackle this problem.

5. Cost and Relevance to Poor Countries. There is no doubt a bright future for new computers and communication technologies for disaster management. Crops are permanently satellite monitored by FAO, famine early warning systems have been developed, menaces of epidemics are identified by satellite remote sensing imagery of the vegetation and related ecological parameters, swarms of desert locusts can be spotted and controlled, victims can be located for search and rescue operations, prediction of floods is now common, timely warning can be given to threatened communities.

New technologies, however, are costly and far beyond the financial capacity of developing countries. This is especially so since some of them are at the same time among the most disaster prone and the poorest countries in the world. It would then be unrealistic and futile to design specific information systems exclusively for disasters. Such systems should be integrated into general planning for development. (For example, monitoring for landslides can be linked with reconnaissance for land use planning.) They should also become part of the general information and communication systems developed at the country level. Advantage should be taken of what is available. Information for disaster management should piggyback the existing facilities and draw on the resources, expertise and imagination of the private sector. When little exists, the need for disaster preparedness could serve as a spearhead to promote better communications.

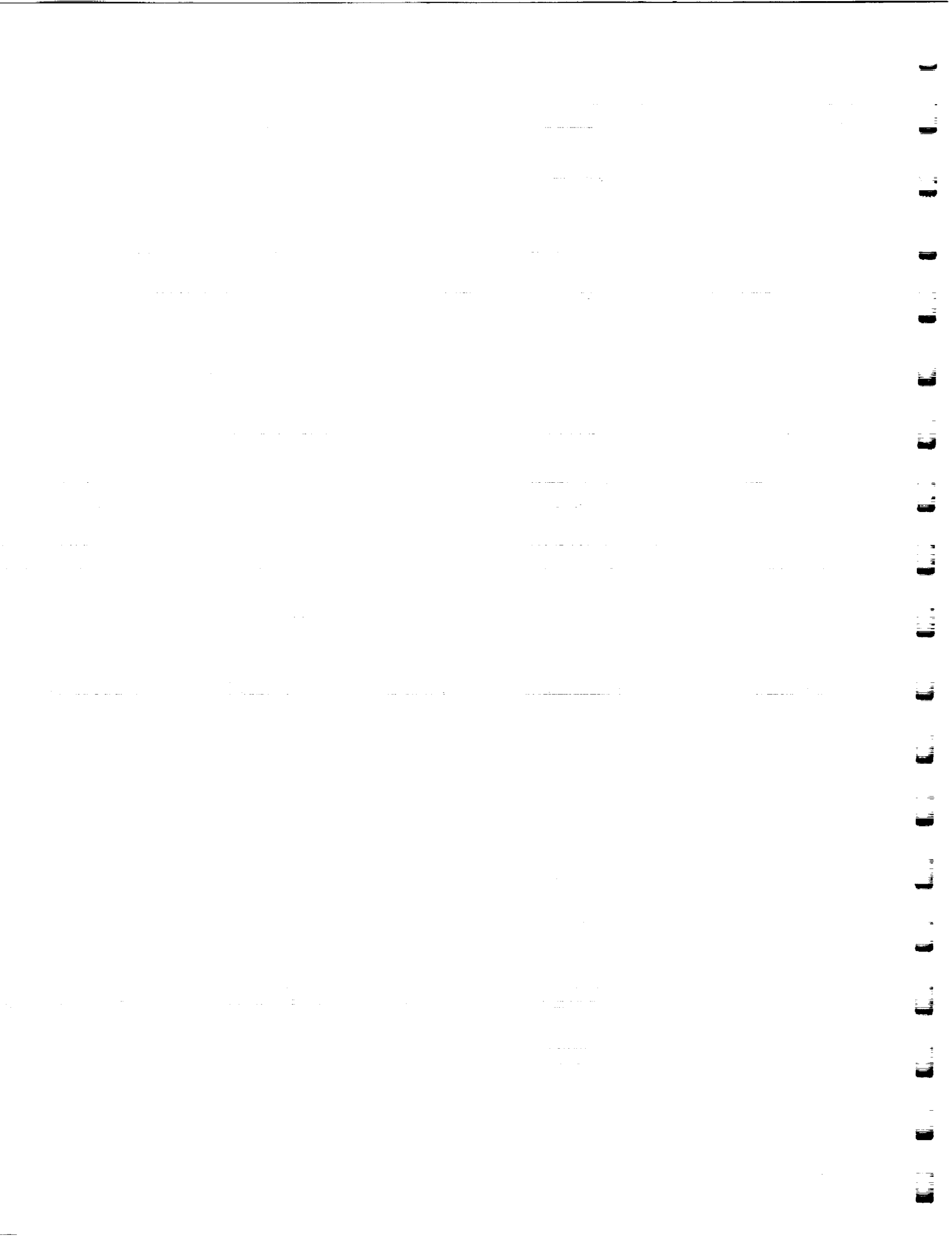
Such systems should be user-friendly and robust as well as relevant to the local needs. Some would say they should be appropriate, but the term of appropriate technology has a connotation of "small is beautiful" which, attractive as it is, smells of amateurism. Advanced technology can also be "appropriate." The microscope after all is a very sophisticated technology and it has been used in the bush for over 100 years.

What adds to the cost is that in order to avoid liability, and to keep credibility, technology must be specific as well as sensitive. That is, it should yield few false positive results, such as giving a false disaster alarm or telediagnosing a disease in a healthy person. While sensitivity is cheap—it costs little to cream out positive signals—specificity is expensive. It is why sensitive tests with poor specificity are widely used in the rural areas of the Third World, and why highly specific diagnostic procedures are so costly in our hospitals. It can be expected that, in the future, due to the spiraling costs of medical care, new batteries of more specific and less expensive tests will be developed for extramural diagnosis. This evolution should be of direct benefit to the poor countries. Cost is not the main issue. The issue again is relevance to the developing world. To quote David Webster, we should be cautious not to "prescribe the rich man's solution to the poor man's problem."

While vested interests may be a factor in the provision of inadequate technology to the developing countries, a more important obstacle could well be misguided humanitarian motivations. The most uncontrollable factor for technological irrelevance is technological philanthropy, that is, the donation of needless equipment. This process leaves the poor countries totally defenseless, for who will refuse a gift? Technological philanthropy is responsible for the huge amounts of costly equipment left unpacked or unused in those countries. It wrecks the little expertise locally available by generating frustration, a sense of hopelessness and a loss of confidence in the people's capacity to solve their own problems.

What above all is important is training and creating the right technological environment, always putting ourselves in the situation of the people whose lives should be improved as a result. This is not a health concern; it is not a disaster concern; it is part of sustainable development in general.

IDNDR, the International Decade, provides us a unique opportunity to explore the potential offered by the emerging technologies, and to promote, develop, and support those technologies deemed adequate to make the next century a safer one, especially in the poorest countries of the world. But all this improvement cannot be accomplished in a vacuum. We must begin now to eliminate pitfalls and illusions. A new attitude must emerge. In the scope of reducing human damages resulting from disasters, we must reconsider the cross-cultural understanding, and reach a real awareness which combines humility with a sense of relativeness. Promoting the right context is essential to the mandate of the Decade.



Tropical Medicine: Telecommunications and Technology Transfer

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Bethesda, Maryland

I have just returned from the Annual Meeting of the ASTMH, where we presented a workshop on "Telecommunications and Technology Transfer" (slide 1). This workshop was a demonstration of some uses of modern telecommunications in medical technology transfer between U.S. and Third World institutions.

I want, first, to say something about the genesis of the idea for the workshop. Some of us are concerned about the potential for global outbreaks of tropical infectious diseases, and about our ability (more correctly, our inability) to identify and respond to such outbreaks. The disease threats I'm talking about include not only the familiar ones like malaria, but also the so-called "emerging" diseases like Lyme, HIV, Lassa.

The rapid increase in international air travel since the 1950s has increased the risk of importation of these diseases to non-endemic areas (slide 2). Meanwhile, the number of people in tropical medicine in the world is small and decreasing, and the capacity to train more of them is limited. This is the situation in the U.S. (slide 3).

We view rapid, efficient telecommunications as part of the solution to this set of problems—the means to link a network of epidemiological field stations via satellite with U.S. academic institutions and government agencies, for purposes of research, training in tropical medicine, and observation of and response to epidemic emergencies.

At the workshop in Boston, we demonstrated applications of telecommunications technology in long-distance consultation, teaching and disaster relief. We also looked at futuristic systems of medically dedicated satellite remote sensors for use in disease prediction and control. I will speak only about applications in teaching and consultation in tropical infectious diseases. Dr. Roberts is speaking later about remote sensing applications in public health.

The organizational and corporate sponsors of the Boston workshop are listed here (slide 4). The program would not have been possible without generous grants from NASA and WRAIR. The other sponsors generously donated equipment and personnel in the production, including a live HD uplink from Walter Reed.

The teleconference was carried live by PBS and the National Broadcast Satellite Network to several hundred medical teaching institutions and VA hospital centers around the U.S.

I now want to present two short videotaped segments from the teleconference. The first was intended to demonstrate how one might use videoconferencing to improve an epidemiologist's knowledge and understanding of a remote area prior to his actually arriving there. By being able to actually see the landscape and its people, and the places where they live and work, study design and logistical preparations are easier. More importantly, by being able to talk face-to-face, study collaborators are able to develop a measure of trust and confidence before actually working together.

(Slide) The scene is Belize. In May 1991, concern that cholera might be spreading north through Central America prompted officials of the Belizean Ministry of Health to initiate a search for possible cases of cholera. (Slide) In the Cowpen area of southeast Belize, banana farm workers reported no illness resembling cholera, but they did express concern about the large numbers of people who were ill with hepatitis. (Slide) Residents pointed to stagnant streams and shallow, foul-appearing wells as the probable source.

(Slide) The Belizean Ministry of Health requested assistance from the joint Belize-U.S. Epidemiological Research Center in Belize City, which is sponsored by USUHS. (Slide) In response, a team of scientists went to Cowpen to collect information and specimens from ill people and their contacts.

The preliminary data indicated that new cases of hepatitis A and B, probably new cases of hepatitis E, and possibly new cases of hepatitis C were occurring primarily among young adults in a population with an extremely high background of hepatitis B.

Seventy percent had hepatitis B markers. Sixteen percent had HBsAg. The hepatitis E and A could have been waterborne.

Through telephone conversations and exchanges by fax, attempts were made to obtain critical data about the involved populations and the important environmental variables. In spite of this, considerable time was required after arrival for repeated revisions of the study protocol. Questionnaires had to be revised and transported by aircraft to and from Belize City for reproduction. If this had been a disease with significant mortality, the time delays and communications problems we experienced would have been much less tolerable.

How could we have planned better? We feel that the most effective means of communication would have been a series of on-line teleconferences conducted in seminar fashion, using satellite television. Unfortunately, the system to support such an undertaking did not exist. It is my goal to create such a system to permit both scheduled and unscheduled teleconferencing with our several overseas programs.

The idea occurred that we could simply use videotapes. What you are about to see is an edited videotape. It contains the sort of information we might have been able to get by teleconferencing if we had the necessary facilities in place:

(Video on:)

Roads—Here we see the roads that are quite vulnerable to heavy rains.

Village—Moving into one of the villages where banana workers live:

*** We see food preparation.

*** We see interested people.

*** And we learn that the local health workers are very interested in health education about water treatment.

*** We also note that there are a lot of people with fevers.

Questionnaire—Here a questionnaire is being evaluated.

Water—Here is a local stream, which is being used for bathing, food preparation, washing clothes, recreation, and as a source of household water.

Wells—This is representative of the local wells. Most are shallow and somewhat protected; however, some are poorly placed, for example, next to latrines.

Water System—Here is a village with a water system. Why does it have a water system, and has the system made any difference with respect to disease incidence?

Lab—Lastly, we are able to look at the up-to-date laboratory and the available laboratory equipment.

(Video off.)

In summary, fax machines, telephones, speaker phones, videotapes, and full-motion TV are all potential means of communicating before initiating a field study. The more sophisticated means, like teleconferencing, offer several advantages, but they are less available.

A second segment of the teleconference in Boston consisted of case presentations of cutaneous leishmaniasis. We used edited HD footage of case presentations collected on-site in Belize and a live HD uplink from Walter Reed Army Medical Center to demonstrate its potential use in teaching tropical medicine in U.S. classrooms. We selected HD to demonstrate its value in situations where a high degree of visual discrimination is needed. Unfortunately, while resolution is good, it is not nearly as good on these regular monitors as it would be on HD monitors. Let me show you one of the cases.

(Video on and off.)

Where are we going from here? Within the context of John Scott's and Jay Sanders's excellent presentations, the objectives I'm about to present may sound somewhat parochial and limited in scope; however, they are things we can probably accomplish institutionally here at USUHS, and they do represent experiential components of a more comprehensive program.

(Slide 5) First, we want to develop a series of teaching modules on selected high-priority tropical infectious diseases, directed toward educating U.S. medical students and practicing physicians. The modules would combine edited videotaped footage collected on-site in endemic

areas, with live interactive videoconferencing conducted by subject matter experts. The sessions would be carried over public broadcasting networks to medical teaching institutions and hospital centers in the U.S. The modules would provide a visual supplement to this manual, "Control of Communicable Diseases in Man."

(Slide 6) Second, we want to develop an operational plan (a plan "on paper") for a deployable telecommunications package that could be used during the acute phases of a disaster. This idea is borne of the frustration of seeing a need for such systems in support of "disasters," but without any organizational mechanism for putting the system together. By the time such a system can be "jury-rigged," cost proposals developed, and necessary coordination accomplished with appropriate agencies, the emergency is over and the problem forgotten until the next disaster.

There is a need to develop telecommunications systems to support international teaching and research programs in tropical infectious diseases, for epidemic observation and response, and for disaster relief. I have tried to describe our limited efforts in this direction so far and our plans for future development. Thank you for your attention.

**DISEASES OF THE TROPICS
TELECOMMUNICATIONS AND TECHNOLOGY TRANSFER**

Workshop Purpose

**Demonstrate uses of telecommunications
in medical technology transfer between
U.S. academic centers and "Third World"
institutions**

SOME FACTS ABOUT INTERNATIONAL TRAVEL

- **One trillion passenger air miles are flown annually—a 20-fold increase since 1950**
- **40 million U.S. citizens travel internationally every year—10-12 million to endemic areas for tropical infectious diseases**
- **6 million foreign tourists and 500,000 immigrants from endemic areas for tropical infectious diseases travel to the U.S. each year**

ASTMH, 1988. Tropical Medicine—Proud Tradition, Grave New Challenges. A statement in support of the Legislative Plan of Action.

**THE U.S. CAPACITY TO ADDRESS
TROPICAL INFECTIOUS DISEASE PROBLEMS***

- No more than 400 clinical tropical disease professionals
- Fewer still with overseas experience
- Only eight U.S. academic tropical medicine "centers"

*BOSTID-IOM Report, National Academy Press, Washington, DC 1987

**DISEASES OF THE TROPICS
TELECOMMUNICATIONS AND TECHNOLOGY TRANSFER**

Organizational and Corporate Sponsors

**Life Sciences Division
National Aeronautics and Space Administration**

Walter Reed Army Institute of Research

REBO Studio, New York City

Hillmann and Carr, Inc., Washington, DC

Scientific Atlanta, Atlanta

**Public Broadcasting System
and its local affiliate
WGBH, Boston**

TELEMEDICINE/DISASTER RELIEF

1. Teaching and Consultation

Produce teaching modules on high-priority infectious disease topics. Modules would include:

- **Videotaped segments of field studies, clinical presentations and laboratory diagnostic procedures**
- **"Live" teleconferences between disease experts and "front-line" health workers**

Modules would supplement established communicable disease texts.

TELEMEDICINE/DISASTER RELIEF

II. Disaster Relief

Develop plans for a deployable telecommunications package to support disaster relief operations, including:

- **System specifications**
- **Equipment and personnel requirements**
- **Operational concepts**
- **Vendors and costs**

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29. The twenty-ninth part of the document is a list of the amendments that were made at the meeting. The amendments are listed in alphabetical order.

30. The thirtieth part of the document is a list of the resolutions that were passed at the meeting. The resolutions are listed in alphabetical order.

31. The thirty-first part of the document is a list of the motions that were made at the meeting. The motions are listed in alphabetical order.

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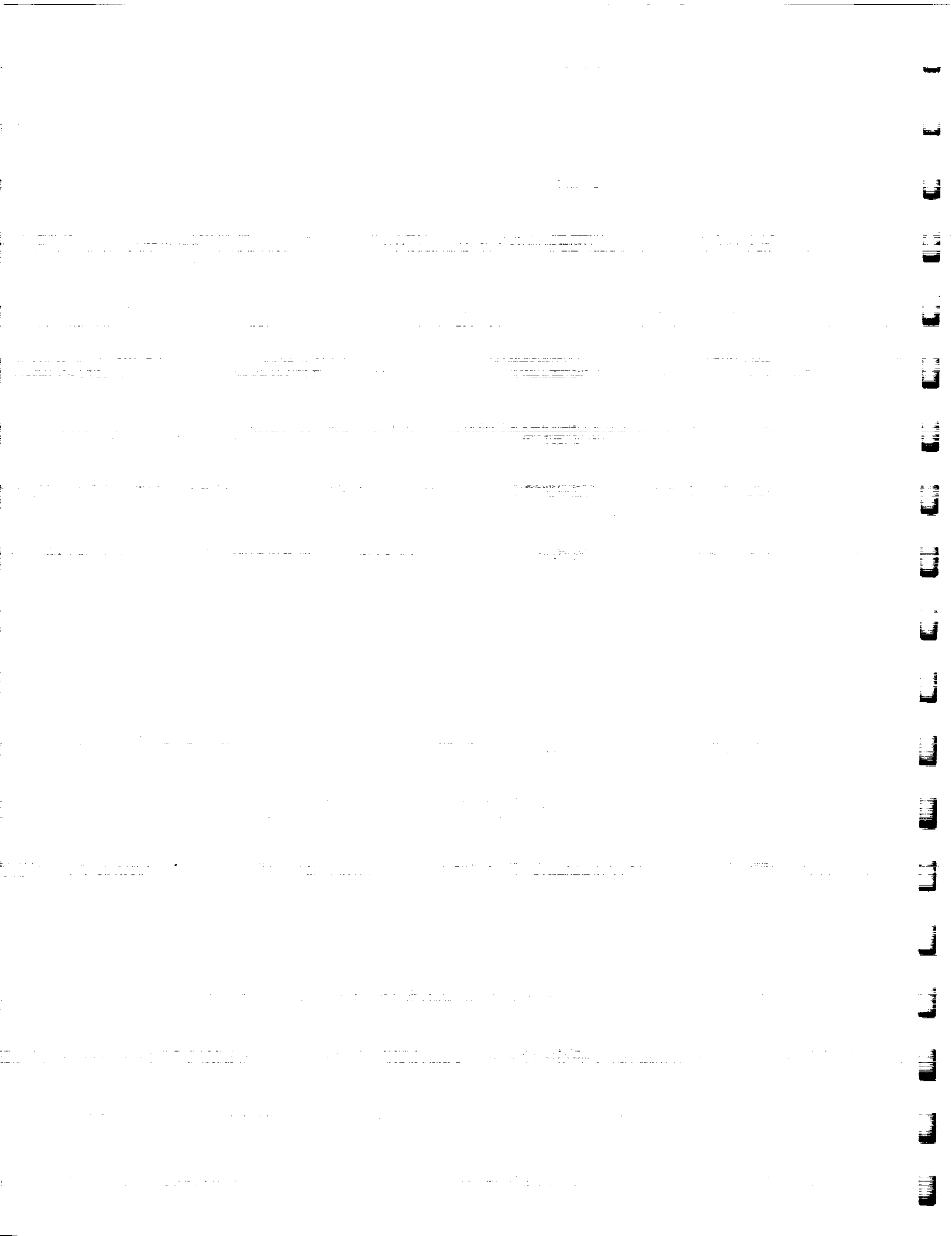
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Applications of the INTELSAT System to Remote Health Care

Andrea Maleter
Manager of Service Assistance
INTELSAT
Washington, D.C.

WHAT IS INTELSAT?

INTELSAT, the International Telecommunications Satellite Organization, is a not-for-profit commercial cooperative of 124 member nations, created on 20 August 1964. It owns and operates a global system of communications satellites that provides international telecommunications services to 180 countries, territories, and dependencies, and domestic telecommunications services to 40 nations.

INTELSAT's services are provided by 18 satellites ringing the globe, far above the equator. Through these satellites, the INTELSAT system links virtually the entire world via full-time/earth station-to-earth station pathways among more than 1,300 antennas.

OVERVIEW

What Are Telemedicine and Disaster Communications? INTELSAT has actively encouraged the use of satellites for both telemedicine and disaster relief: two quite different applications which at time overlap in function.

Telemedicine usually refers to some kind of ongoing, daily program, whereby physicians and health administrators can communicate with patients or other health administrators in remote areas via satellite. Telemedicine requirements might encompass medical file transfers, transmittal of public health information, remote testing and diagnosis, or audio and video conferencing. Earth stations and all related equipment may be either somewhat permanent in nature, or transportable. The use of transportable equipment is increasingly on the rise, as technology improves quality and lowers costs. These transportable earth stations operate with an existing medical care or public health care facility, being mounted on a vehicle that can be driven from site to site and operated for days and sometimes even months at a time.

Disaster telecommunications (which frequently encompass telemedicine applications) are those communications required under special circumstances, for example, in the aftermath of earthquakes, floods, tidal waves, or eruption volcanoes. These conditions create urgent,

immediate needs for communications facilities in unpredictable locations. The disrupted communications system has to be replaced immediately by a new system and the most effective way to do this is via satellite.

Telemedicine and disaster telecommunications are not a specific, separate INTELSAT service, but new communications systems can be set up in a very short time via INTELSAT's existing infrastructure and service offerings. The wide variety of applications available through INTELSAT, provides the flexibility necessary to establish emergency communications on a rapid basis.

INTELSAT Telemedicine and Disaster Telecommunications Applications. INTELSAT has a number of services which are most readily utilized for telemedicine and disaster telecommunications. They are:

- access to domestic/regional networks already in place
- temporary services using transportable earth stations
- INTELNET leases for very small aperture terminals (VSATs)
- Project Access.

INTELSAT DOMESTIC/REGIONAL SERVICES

Satellite communications are a vital tool to foster economic and social development, since they provide a cost-effective method to link a country's urban and remote regions. INTELSAT domestic services let countries have access to satellite capacity on an incremental basis, while avoiding the costs and risks of designing, procuring, launching and operating their own satellite program.

INTELSAT has offered capacity for domestic service since 1973, and currently some 40 countries throughout the world rely on INTELSAT to meet national telecommunications requirements. INTELSAT offers a range of domestic services meeting all types of applications. Each domestic network can be tailored to meet a country's specific communications traffic and geographical requirements.

INTELSAT has introduced regional services as an extension of its domestic services to allow the use of INTELSAT capacity for a mix of domestic and international traffic. Regional services enhance connectivity between neighboring countries with geographic, cultural, and economic ties.

Domestic/regional telephone and television services are available in pre-emptible and non-pre-emptible leases. These services are carried on six INTELSAT satellites in the three ocean regions.

Applications of Domestic/Regional Services. INTELSAT's domestic satellite services are generally used for national terrestrial networks for a wide range of applications, including:

- television and radio broadcasting
- public switched telephony
- public data networks
- private business networks
- remote audio conferencing for health care
- medical data networks/file transfer.

All of these applications can be used for telemedicine as well as disaster communications.

In cases of disaster, an existing lease held by one country can even be used for its own or a neighboring country's emergency communications. These communications can be established using both earth stations that are already in place or through the temporary use of transportable antennas to access disaster sites.

USE OF TRANSPORTABLE ANTENNAS

Transportable satellite uplinking is the fastest growing application in the international television business. Today, 27 INTELSAT member countries have pre-registered 280 C/Ku-band antennas with the INTELSAT system that can be flown to and operated from anywhere in the world.

These antennas are used routinely to broadcast live news from locations where major events occur—the crisis in the Persian Gulf region or the excitement of the World Football Cup matches—and of course are invaluable in relaying images, news and information from disaster sites. The antennas are mostly in the range of 1.6 to 1.8 meters in size.

In addition to the video links provided via satellite news gathering teams, INTELSAT also provides a flexible medium for short-term voice and data communications with remote locations under emergency conditions. Very small, readily transportable earth terminals similar to those for news gathering can also be deployed for voice and data communications within what INTELSAT calls the INTELNET service.

For day-to-day and week-to-week remote health care, transportable earth stations are a perfect medium of communication between hard to reach locations where perhaps a single paramedical worker can be linked through a small terminal to specialized doctors at a central hospital facility. Such links could provide voice as well as video conferencing, facsimile, data and other vital services.

INTELNET

INTELNET offers a flexible lease mechanism for voice and data distribution networks. It is most frequently used by banks, insurance companies, news agencies, oil and gas companies, government agencies and other multinational organizations. It permits access close to the customer's location, and can be configured to meet specific communications requirements with minimum technical and operational restrictions.

INTELNET is a digital service designed for use with very small aperture terminals (VSATs) at many remote points operating with a larger central hub earth station. The communications system consists of two parts—a hub station and a remote station to provide one channel of interactive service. A hub station consisting of a transmitter and receiver requires at least a Standard B antenna (10 to 13 meters).

The hub station is not part of the remote station and is usually housed at an existing earth station. These hubs could, for example, be operated on an international gateway antenna of any country, or an antenna used as part of a country's domestic lease. The remote stations can be easily moved and operated from any site from which the satellite to be accessed is "visible." The remote station consists of a 1.2 meter antenna and a transmitter and receiver. While antennas as small as 0.6 meters are used for receive only proposes, the 1.2 meter antenna is currently the smallest antenna for an interactive service. There are systems in development with smaller antennas than 1.2 meters, and INTELSAT is now working to develop a system with a suitcase size terminal of 0.6 meters that operates off of simple battery power. Such a system provides optimum flexibility for both telemedicine and disaster applications.

INTELNET is offered on a global C- and Ku-band, and is offered as a leased transponder service, available in any multiples of 100 KHz (1 MHz, 5 MHz, 9 MHz, 18 MHz, 36 MHz, and 72 MHz). INTELNET can operate with various modulation, coding, and multiple access techniques.

Since INTELNET is offered on a full and fractional transponder basis, the space segment is defined in terms of a resource allocation of bandwidth and power. Users design their own transmission parameters to operate within their leased space segment and this, along with the modulation technique, is assessed as appropriate for use in the INTELSAT system when a transmission plan is submitted. Thus, INTELNET in effect can be used to meet virtually any communications need.

Fourteen INTELNET networks are now in operation, most in the Indian and Pacific Ocean Regions. Each network typically consists of 50 or more VSATs operating with a central hub station which is provided at a gateway earth station. The most common use of INTELNET to date has been for the worldwide distribution of news information, news photos and financial

information. INTELNET is, however, ideally suited to provide thin-route networks for telephony as well as data using very small terminals at low cost, and with considerable flexibility for expansion.

VSATs are an excellent option for telemedicine, with applications that can provide voice, data and fax services. This is particularly true given the low cost of a small microterminal for use within an INTELNET work, something which is going down practically every month.

For both telemedicine and disaster relief efforts, use of these VSAT terminals in either a stand-alone network or in connection with an existing domestic lease can provide rapidly deployed and extensive communication. In addition, data collection networks using INTELNET can also be a valuable tool in disaster prevention. By placing VSAT terminals with seismic or other sensing devices in disaster prone areas, a network can be established with a national or regional hub station to monitor activity and plan for emergency applications. Such networks are effectively used throughout Italy for example, for flood control and seismic sensing.

Summary of Existing Interactive INTELNET VSAT Applications

1) INTELNET leases:

Hub antenna sizes : from 7.2 m to 30 m

Remote antenna sizes : from 1.2 m to 4.5 m

2) Domestic leases or transponder purchases: These networks can be tailored to each country's specific needs. Thus there is a broader spectrum of network topologies, modulation techniques, and applications. The characteristics of these networks can be summarized as follows:

C-band hub antenna sizes : from 7.3 m to 11.0 m

C-band remote antenna sizes : from 1.8 m to 4.6 m

Ku-band hub antenna sizes : from 4.6 m to 13.0 m

Ku-band remote antenna sizes : from 1.8 m to 4.6 m

VSAT-to-VSAT. Telecommunications links between VSATs can be very effective for telemedicine or disaster communications. For example, doctors can compare diagnoses and rescue teams could communicate with each other directly from remote locations. Further, communications networks can be established for continued relief operations spanning the weeks and months after the initial emergency. The technical features of such networks can vary depending on the circumstances of each case. Variables that would need to be considered include:

- The satellite accessed
- The frequency band (C-or Ku-band)
- The modulation technique
- The bandwidth used.

USING THE EXISTING TELECOMMUNICATIONS INFRASTRUCTURE FOR REMOTE HEALTH CARE APPLICATIONS: PROJECT ACCESS

During the mid to late 1980s, INTELSAT sponsored a special program to promote satellite use for health and educational purposes. For 3 years Project SHARE, as it was called, demonstrated diverse and often exciting examples of telemedicine. Today, Project Access has superseded Project SHARE, streamlining the program while at the same time continuing to show users how INTELSAT can bring health care to some of the loneliest points on the globe.

Project Access can provide free use of the INTELSAT space segment for education, health or other closely related social services. Like its predecessor, Project Access was designed to stimulate service to rural and remote areas, while at the same time emphasizing the potential for follow-on commercial service. As such, preference is given to applicants that require only audio or data services who have operational and financial plans to implement a regular commercial service. A high priority is also awarded to projects that are developing or testing new technologies/applications in remote areas and then apt to be converted to commercial service. Project Access will also provide up to 4 hours of free space segment for special global television events that are sponsored by any of the principal organs of the United Nations, and which are clearly for humanitarian purposes.

Under Project SHARE, some of the most interesting activities were those of Dr. Max House, who used INTELSAT to provide a dedicated narrowband audioconferencing link between the Kenyatta Medical School in Nairobi, Kenya; the Makerere Medical School in Kampala, Uganda; and the Health Sciences Centre in St. John's, Newfoundland Canada. This link allowed EEGs and EKGs to be sent from African cities to Canada, where sophisticated computers and experts could undertake diagnoses and recommend treatments. Weekly audio conferences permitted medical students in Uganda to participate in lectures, rounds and other educational sessions at the hospital in Kenya. Dr. House also established a similar telemedicine link over the INTELSAT system to Jamaica.

Under Project Access, in March of this year INTELSAT provided capacity for a special videoconference to over 30 Latin American countries, for the Third Pan American Teleconference on AIDS. Sponsored by the Pan American Health Organization and the World Health Organization, this videoconference lasted 3 days, bringing together hundreds of health experts from around the world to discuss one of the most pressing issues of our time.

INTELSAT'S ROLE IN DISASTER TELECOMMUNICATION EFFORTS

Is it possible to provide telecommunication links in sudden disaster situations? Yes! There are many examples that demonstrate INTELSAT's flexibility for providing telecommunications in a disaster; these have included requirements for emergency communications in Iran, the Philippines, Bangladesh, Colombia, Mexico, the U.S.S.R., and the U.S.

Iranian Earthquake. In June 1990 Iran suffered a devastating earthquake, severely disrupting communications between the stricken regions and the rest of the country. INTELSAT loaned Iran a portable communication systems to link the earthquake-affected villages with the public switched telephone network. It took 2 days to set up the communication link and 2 days more to teach the Iranian technicians. INTELSAT's emergency relief network continued to provide valuable communications for several months between the stricken area and the rest of the world.

Medical Assistance to the Armenian Earthquake Victims. For several months in 1989, INTELSAT and its U.S. signatory COMSAT joined NASA in a U.S.-U.S.S.R. satellite medical assistance demonstration project, designed to make U.S. medical expertise available to victims of the December 1988 Armenian earthquake. The space segment was provided 4 hours per day, 5 days per week.

INTELSAT provided free space segment for this "Telemedicine Spacebridge" project, which connected specialized medical facilities around the U.S.A. with the Diagnostic Center in Yerevan, Armenia. This made possible live consultation between medical experts in the two countries on the treatment of earthquake victims with long term physical and psychological trauma.

The INTELSAT system also has been used successfully for emergency communications during such international disasters as Hurricane Gilbert and the Mexico City earthquake, demonstrating INTELSAT's flexibility in providing disaster telecommunications needs.

Natural Disaster in Bangladesh. As an aftermath of the recent natural disaster in Bangladesh, one of the two INTELSAT earth stations was incapacitated. INTELSAT immediately made 13 circuits available to Bangladesh on a temporary basis, and also offered a portable earth station until the regular communications links were restored. In addition, an INTELSAT staff member went to Bangladesh to assess the damage done to the earth station.

HOW INTELSAT'S EXISTING INFRASTRUCTURE CAN BE USED FOR DISASTER TELECOMMUNICATIONS

Time is of the essence in establishing a disaster telecommunications network. Use of INTELSAT's existing earth stations to establish disaster telecommunications links is the speediest

alternative. These systems can serve as the hub for VSAT networks configured to respond to the communications requirements of the particular disaster. Naturally, it will take longer to establish a disaster relief network if no hub earth station or VSAT is available.

If there is no transportable earth station available within the affected country, it could seek assistance from other countries. With 17 satellites in orbit and more than 1300 antenna stations in operation worldwide, INTELSAT can facilitate the implementation of the required telecommunication links in a short time.

INTELSAT's INTELNET service is a highly flexible tool for disaster relief, and could also be successfully applied to telemedicine. A special application for INTELNET is the use of data collection networks using VSATs. Data collection with seismic or other sensing devices in prone areas is very important for disaster prevention and the planning of disaster relief operations. Similar data collection networks could be adapted for use by health officials monitoring outbreaks of certain diseases, or for audioconferencing between doctors and nurses in the field and at base hospitals.

It is also important to have emergency contingency plans which can provide disaster communications for different kinds of emergencies. Such plans could shorten the time required for implementation of a disaster communications network.

These plans should show how to set up the telecommunications links in different cases, where the best positions are for transportable terminals, and which earth stations and satellite capacity could be used. For such plans it is important to have agreements with neighbor countries or other nations, including possible support of their infrastructure.

INTELSAT is prepared to work together with administrations or organizations to develop preventive disaster relief plans. An adequate infrastructure using preventive data collection (INTELNET service) and disaster telecommunication planning is the way for optimal disaster telecommunications relief.

The UN and INTELSAT. INTELSAT has provided lease capacity for telecommunications service to the United Nations since 1983. The capacity is used for telecommunications between UN Headquarters and UN personnel engaged in peacekeeping and emergency relief missions. The emergency relief activities include natural disasters, epidemics, famines and environmental emergencies, all of which typically cause extensive loss of life and/or property and require prompt international response.

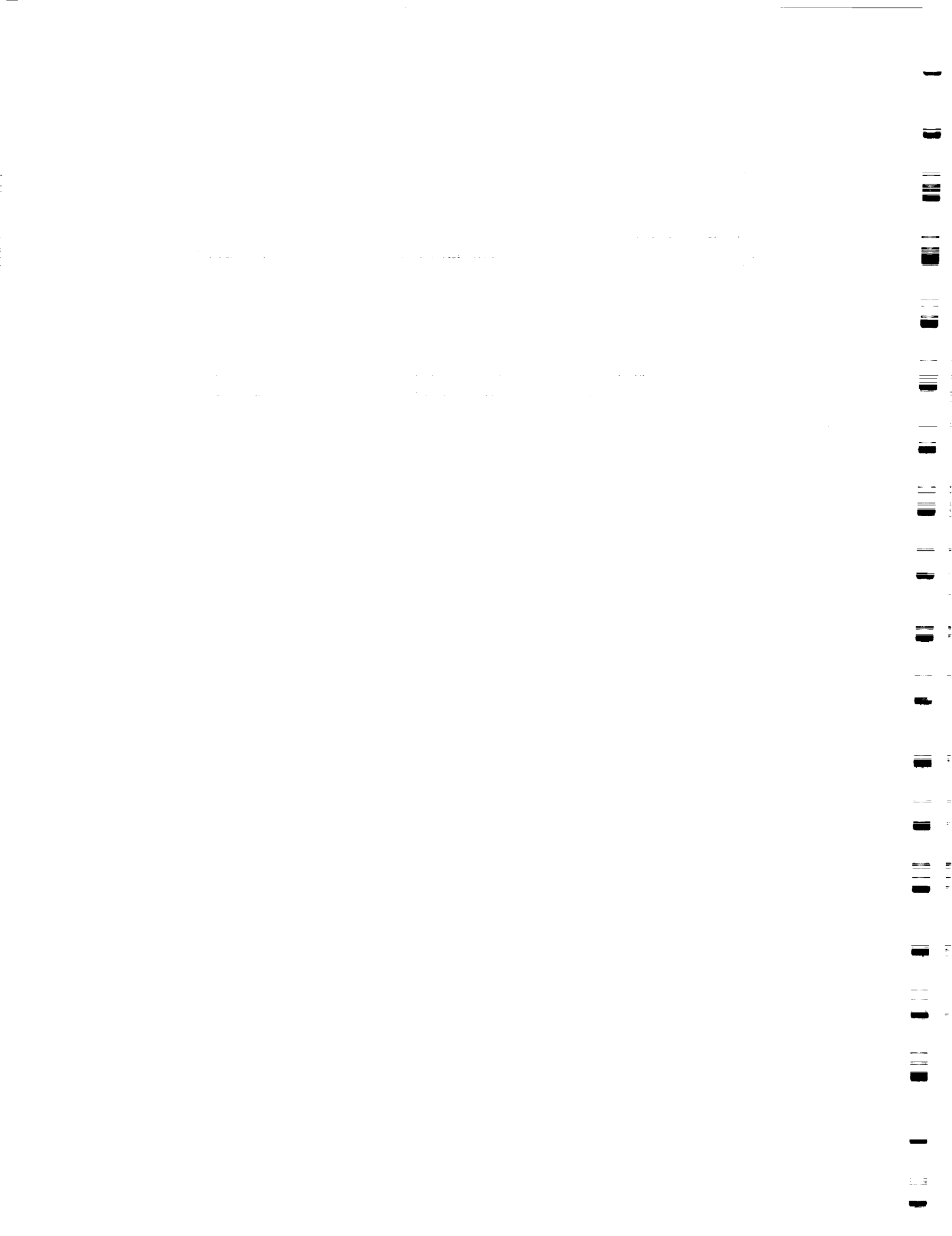
There are currently three such INTELSAT leases, two of 9 MHz each in the AOR, and one 9 MHz lease in the IOR. The UN earth stations operating with these leases are increasing, and there are now hubs in New York and Lebanon. While to date these UN facilities have only been used by the peacekeeping forces, a review is now underway of expanding their use for disaster situations to provide emergency communications.

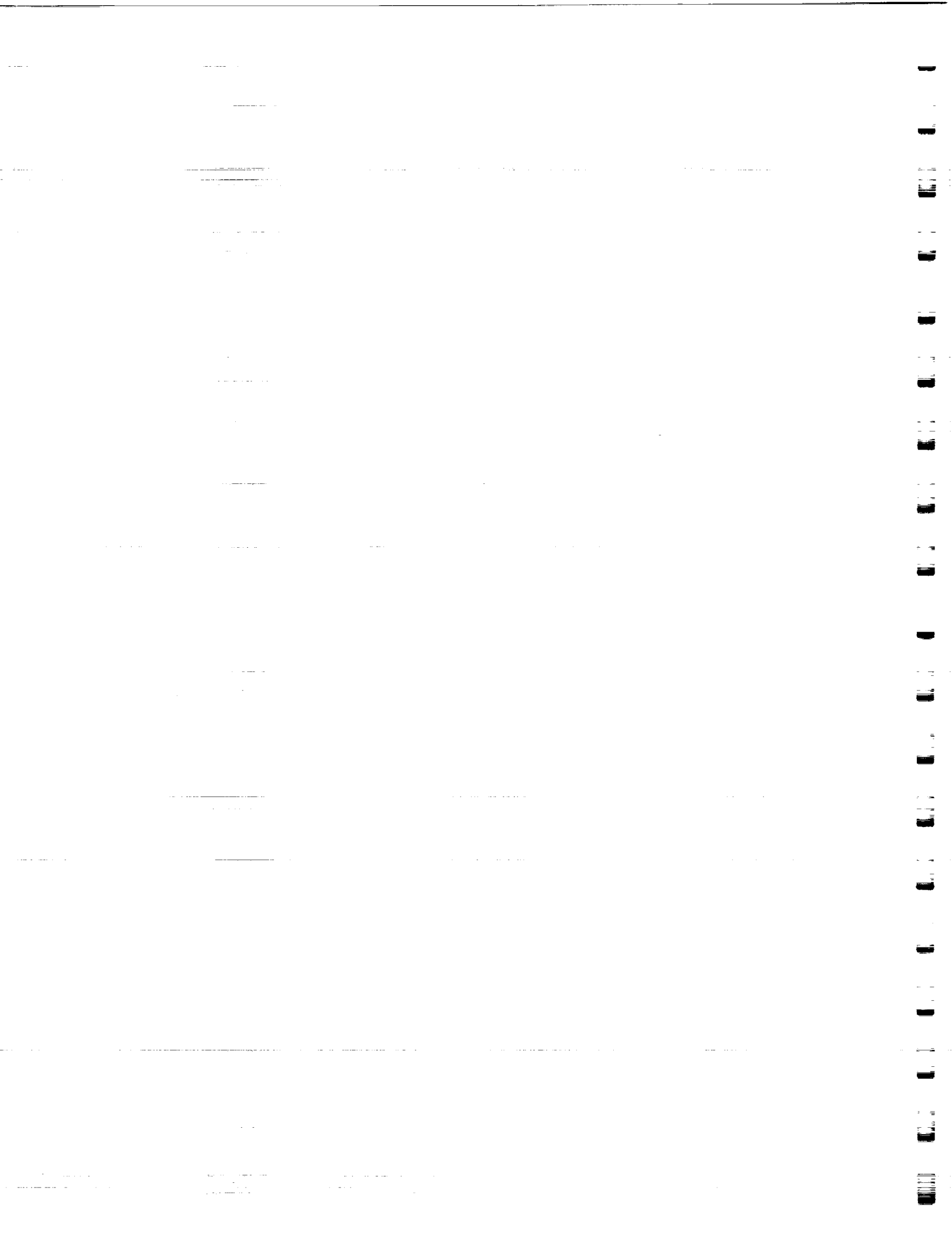
THE FUTURE

Global View. Demand for INTELSAT services increases every year. INTELSAT's international and domestic services for voice, data and TV are currently provided over 15 satellites. Eight additional satellites currently on order: the INTELSAT K, which will be deployed in the AOR in 1992; five INTELSAT VII's, the first of which will be deployed in the POR in 1993; and two INTELSAT VII-A's.

The INTELSAT VII series features significantly increased power and coverage capability, enabling provision of service through a new generation of smaller and less expensive ground stations.

Future of Telemedicine and "Disaster Telecommunications." INTELSAT's domestic/regional services, transportable antenna capabilities, and INTELNET service have potential applications for both telemedicine and disaster communications. INTELSAT is a dynamic, user-responsive organization that continually seeks to enhance its global telecommunications abilities. The INTELSAT system, with its wide range of services and global connectivity, is in a unique position to provide doctors and relief workers reliable and easily operable communications, for both planned services and those that are needed at a moment's notice.





Clinical Aspects of Telemedicine

Ronald C. Merrell, M.D., F.A.C.S.
Associate Dean and Clinical Affairs Professor
Department of Surgery
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Communication among physicians is an essential in order to combine our experiences for the elucidation and application of new knowledge and for the accurate and uniform application of established medical practice. This communication requires and adequate understanding of the culture of the patient and the social context of disease and indeed the culture of the physician. Malnutrition in Bangladesh means caloric insufficiency, and a program to lower cholesterol would be impertinent, while a program to enhance the nutrition of patients in Texas by an international effort to import more grain would be ludicrous. In the same vein a public health effort to combat alcoholic cirrhosis in Mecca would be as silly as a program to increase fiber in the diet of the Bantu. Clinical communication must acknowledge the culture of the issue at hand and the differences in the experiential base of the physicians. Not only do geography and culture affect the potential differences in the experiential bases, but the world utilizes very different traditions of education and science in training physicians. We are influenced by the diseases we treat, and learn to look for the expected at least as much as we are attentive to the unexpected. A physician in Siberia would be much more likely to recognize frostbite than one from Buenos Aires, and the Argentine doctor would much more likely consider Chaga's Disease to explain abdominal pain than a colleague in Zurich. Beyond these obvious issues in communication among physicians we must deal with the many languages and idioms used in the world.

The need for communication is not diminished by the differences among physicians. We must share our experiences, our science, and our humanity in order to bring forward the new, to expunge the useless and to realize the synergism of international medicine. In times of crisis when the very fabric of a local health system is strained and threatened we must communicate sufficiently to permit assistance and cooperation across even great distances. When the Republic of Armenia sustained its disastrous earthquake in December of 1988 there was a profound urge among physicians throughout the world to assist our colleagues, and some of us were fortunate to do so in a small way through the Telemedicine Spacebridge. I have every confidence that had the situation been reversed the colleagues I found in Armenia and Russia would reciprocate in a flash.

Therefore, I believe we must examine the experience we shared in order to prepare for the next inevitable disaster.

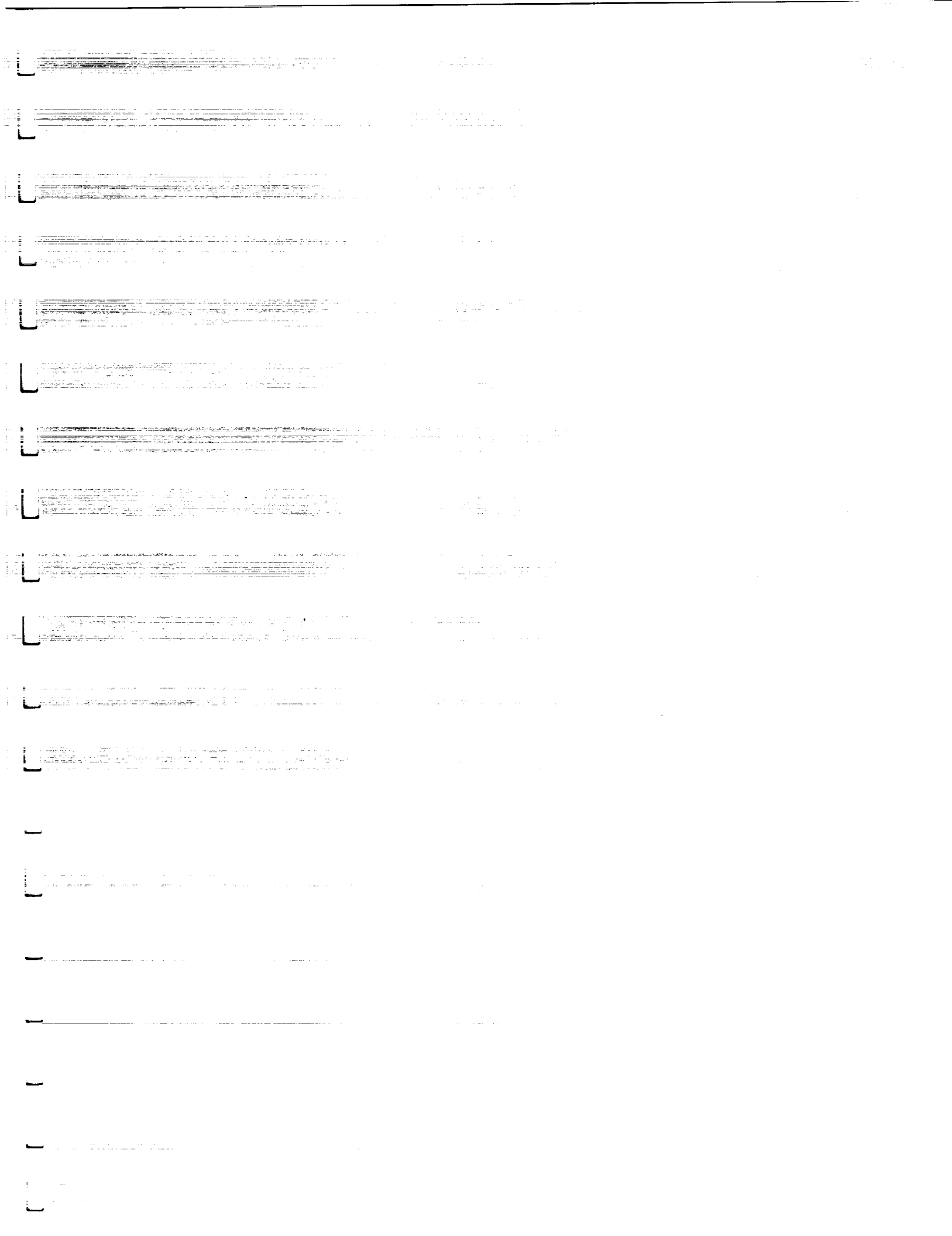
The major characteristic of the Telemedicine Spacebridge was medical communication. The equation of the communication brought into relationship consulting physicians in Armenia who had primary responsibility for the patients and consultant physicians in the United States. The features of the consulting physicians which were important for success included full recognition of the experiential differences between our systems of education, our practice, our culture and language. At that point it was important for the consulting physician as the initiator of the relationship to identify the problems we should discuss. This required great understanding of the clinical problem as recognized in Armenia and the framing of the question to be discussed with great clarity. Given the complexity of the differences in experience and practice, the question required a very clear format for presentation of the background of the patient and a full knowledge of the technology we would use for the communication. The communication itself would entail words in print and images and sounds which then were to be processed at the other end into accurate concepts which were as similar as possible to the original concept of the consulting physician. When the consultant responded it was imperative that the consulting physician understand the response with reference to the issue or the patient at hand and that the consulting physician have confidence in the consultant. This kind of confidence is normally developed over years among colleagues in a given specialty, but in this case the confidence was needed promptly. In order to accomplish this there was a variety of conferences to share experience and expertise, which established the peer relationship among the participating physicians. Credentials were also offered and credibility was bolstered by offering as much in the way of personal published information as possible. In order for the communication to satisfy the test of usefulness the consulting physician had to be willing to consider changing the approach and management of a particular patient. Without a generous willingness to incorporate the new information into action in patient care the purpose of the communication in reference to the actual medical disaster would have failed.

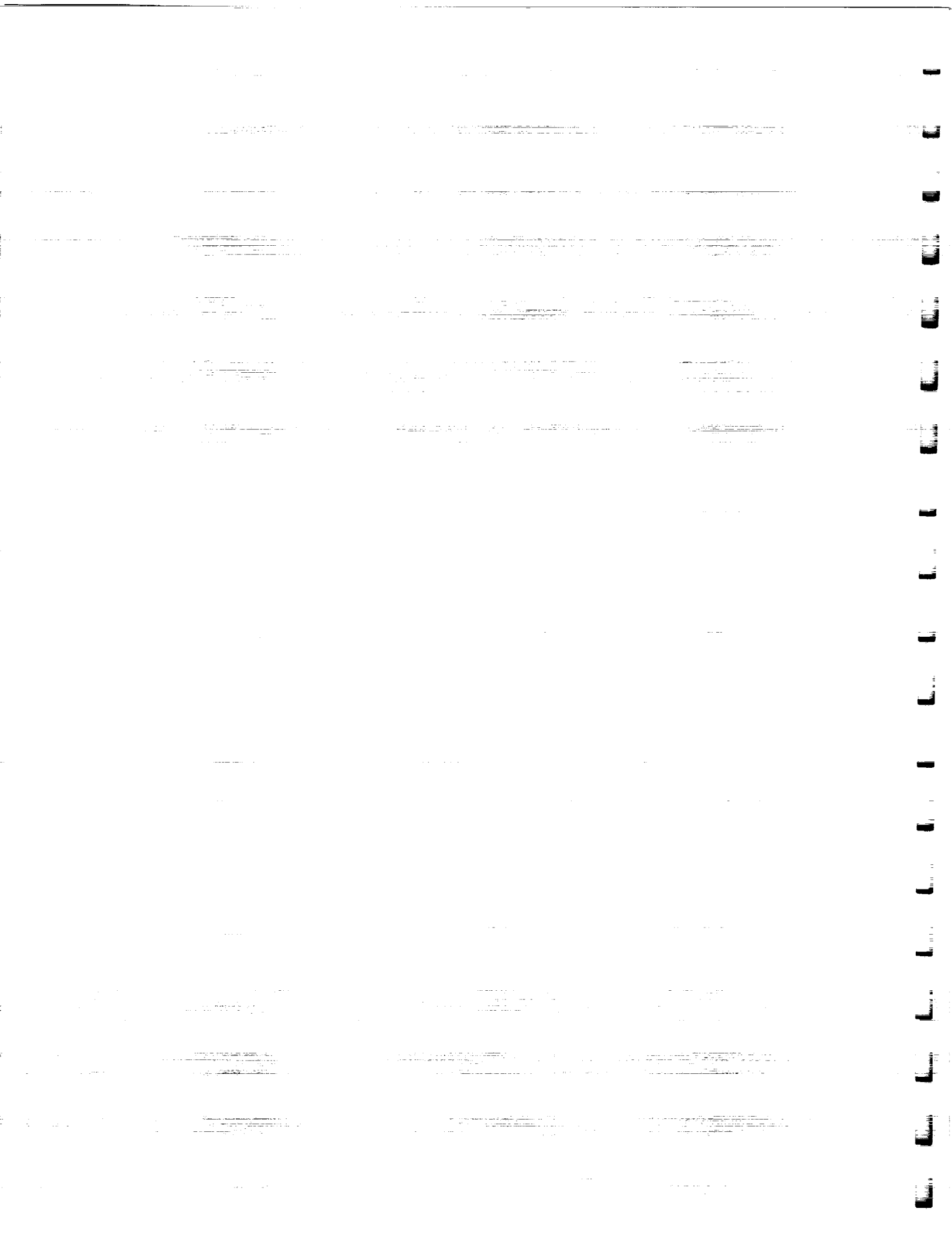
The features required of the consultant physician were quite similar, as one might expect, to those of the consulting physician if the objective was an equation or relationship which would lead to improved patient care. Certainly the consultant needed to understand the generic problems of patients following the disaster and to have sufficient expertise to be a worthwhile collaborator. The consultant was required to adequately understand the question and to recreate the concept of the consulting physician in order to summon the confidence to respond to the question with information that might be translated into a new management plan for a patient the consultant would never see. This sense of personal responsibility on the part of the consultant to at least approximate that of the primary treating physician in Armenia was critical to the relationship. The

consultant also had to be willing to abandon preconception and incorporate new knowledge contributed by their Armenian counterpart into the response.

The overriding feature of the relationship was one of professional trust, employing the mediation of an extraordinary technology. It was clear from the outset that the technology was not an end to itself but a conduit for the engendering of professional trust and reliance. The proof of effectiveness was to be the implementation of useful clinical activities developed by new colleagues in a peer relationship of international medicine.







NEW TECHNOLOGY APPLIED TO TELEMEDICINE

BY

**EDWARD F. MILLER, Ph.D.
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N 9 4 - 1 1 7 9 6

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MEDICINE CONFERENCE
UNIFORMED SERVICES UNIVERSITY OF THE
HEALTH SCIENCES
BETHESDA, MARYLAND
DECEMBER 9-11, 1991**

1.0 INTRODUCTION

SATELLITE COMMUNICATIONS TECHNOLOGY HAS BEEN USED FOR ESTABLISHING INTERNATIONAL
TELEMEDICINE COMMUNICATIONS LINKS IN A NUMBER OF INSTANCES, (E.G., TELEMEDICINE SPACE
BRIDGE BETWEEN ARMENIA AND THE UNITED STATES IN 1989, AND THE PROPOSED LINKAGES
SHOWN IN THE FIGURE, FOR DEMONSTRATION DURING THIS CONFERENCE AND DURING 1992 AND
1993). IN THE CURRENT EXAMPLE, GEOSTATIONARY SATELLITES ARE USED TO PROVIDE
INTERCONTINENTAL COMMUNICATIONS LINKS BETWEEN THE TWO COUNTRIES AND ALSO FOR
DISTRIBUTION WITHIN EACH COUNTRY.



AEROSPACE TECHNOLOGY DIRECTORATE

SPACE ELECTRONICS DIVISION



SATELLITE COMMUNICATIONS, TECHNICAL CHARACTERISTICS

WSDRN SATELLITE

ANTENNA DIAMETER
TRANSMITTER POWER

1.6 m OR 3.0 m
13 W

WSDRN EARTH STATION

ANTENNA DIAMETER
TRANSMITTER POWER

2.0 m OR 5.0 m
100 W OR 240 W

US DOMSAT

ANTENNA DIAMETER
TRANSMITTER POWER

1.6 m
20 W

DOMSAT EARTH STATION

ANTENNA DIAMETER
TRANSMITTER POWER

3.7 m, TYPICAL
300 W OR 600 W



AEROSPACE TECHNOLOGY DIRECTORATE

SPACE ELECTRONICS DIVISION



TECHNICAL CHARACTERISTICS OF CURRENT TELEMEDICINE LINKS BY SATELLITE

SATELLITE ANTENNAS

1.6 TO 3.0 m

SATELLITE TRANSMITTER POWER

10 TO 20 W

EARTH STATION ANTENNAS

2 TO 5 m

EARTH STATION TRANSMITTER POWER

100 TO 600 W

CHANNEL BANDWIDTH FOR ANALOG VIDEO

34 TO 54 MHz

FREQUENCIES

Ku-BAND 11-15 GHz



AEROSPACE TECHNOLOGY DIRECTORATE

SPACE ELECTRONICS DIVISION



Lewis Research Center

APPLICATIONS OF NEW TECHNOLOGY

VIDEO CODING

- REDUCES BANDWIDTH & POWER REQUIRED
- PRESERVES FULL MOTION AND FULL RESOLUTION

APPROACH

- DEVELOPMENT OF VIDEO CODING ALGORITHMS
2:1, 5:1, 10:1 COMPRESSION
- PROTOTYPE EQUIPMENT
- DEMONSTRATIONS WITH SATELLITES

BENEFITS

- LOWER COST OF TELEMEDICINE TRANSMISSIONS
- MULTIPLE TELEMEDICINE CHANNELS IN A SINGLE SPACECRAFT TRANSPONDER
- REDUCED POWER, SMALLER ANTENNA SIZES

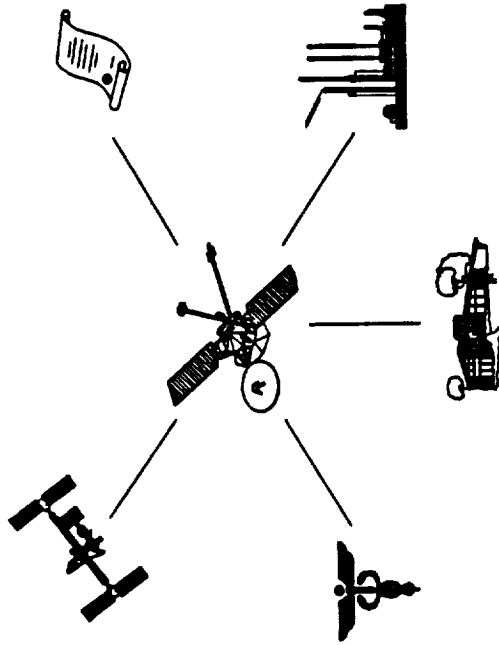


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VIDEO COMMUNICATIONS BANDWIDTH COMPRESSION



SCOPE/OBJECTIVES:

- DEVELOP VIDEO DATA COMPRESSION TECHNOLOGY FOR TRANSMISSION OF IMAGE DATA OVER SPACE COMMUNICATIONS LINKS
 - EFFICIENT BANDWIDTH UTILIZATION
 - INCREASED PROCESSING SPEED THROUGH EFFICIENT CODING TECHNIQUES
 - COST EFFECTIVE HARDWARE IMPLEMENTATION

BENEFITS:

- INCREASE ORBIT/SPECTRUM CAPACITY
- ENABLE COST EFFECTIVE COMMERCIAL DIGITAL VIDEO TRANSMISSION
- ENHANCE NASA SCIENCE MISSION VIDEO CAPABILITIES
- REDUCE SPACE SEGMENT COSTS BY REDUCING BANDWIDTH REQUIREMENTS

ACCOMPLISHMENTS:

- PATENT PENDING ON IN-HOUSE DEVELOPED ENHANCED DPCM CODEC PROVIDING BROADCAST QUALITY ENCODING IN REAL TIME
- UNIVERSITY GRANTS IN PLACE FOR INVESTIGATION AND DEVELOPMENT OF NEW ENCODING TECHNIQUES
- RECENT SCAR AWARD TO COMSAT FOR DEVELOPMENT OF FLEXIBLE-RATE HDTV CODEC



AEROSPACE TECHNOLOGY DIRECTORATE

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APPLICATIONS OF NEW TECHNOLOGY (CONT.)

SPOT BEAM & MULTIPLE BEAM ANTENNAS

- FOCUS SPACECRAFT POWER ON INTENDED REGIONS
- HIGH GAIN SPACECRAFT RECEIVE ANTENNA

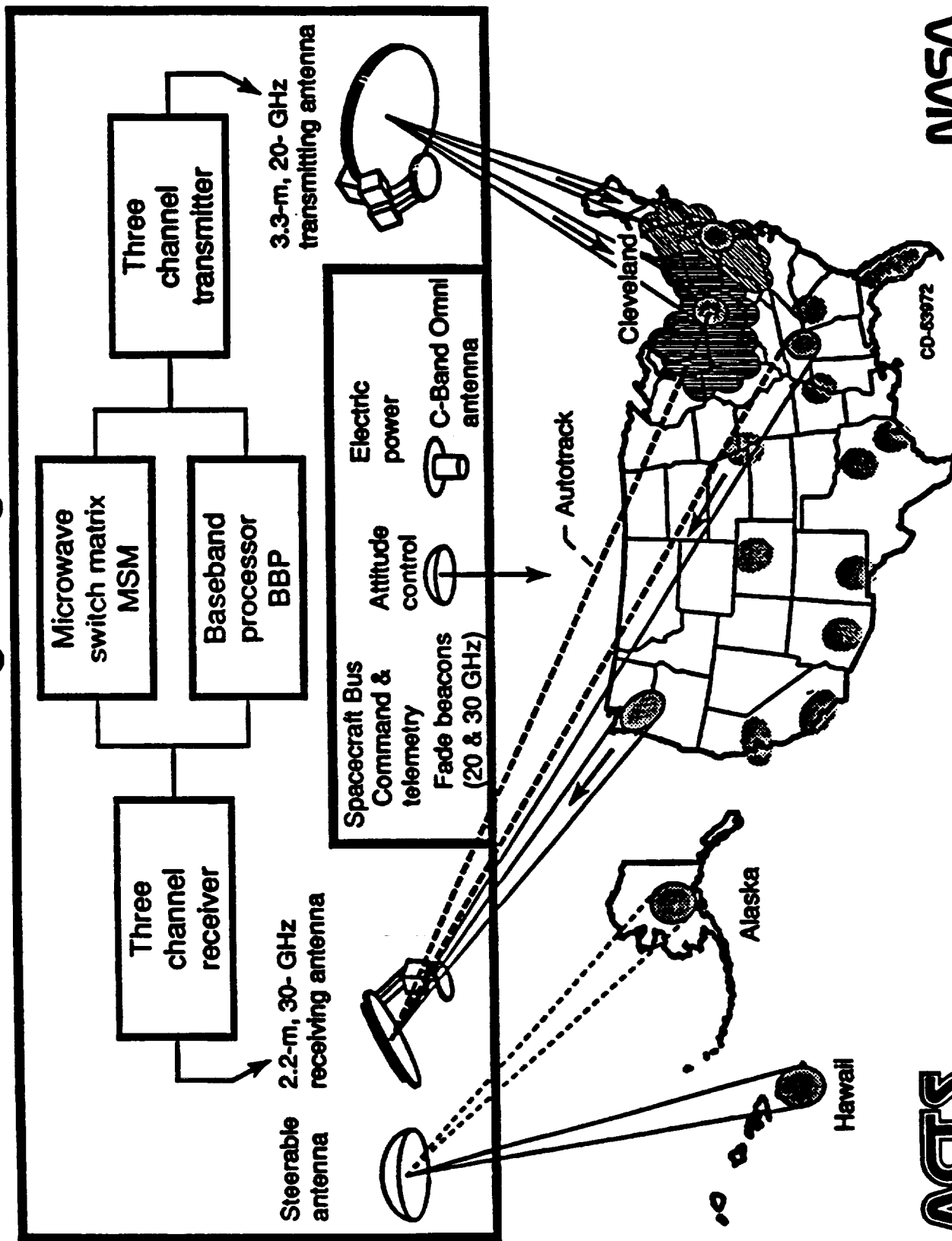
APPROACH

- MULTIPLE FEED ANTENNAS FOR MULTIPLE SPOT BEAMS
- ARRAY ANTENNAS FOR SCANNING BEAMS
- PROTOTYPE HARDWARE
- SPACE EXPERIMENTS/DEMONSTRATIONS

BENEFITS

- REDUCED POWER & COST PER TELEMEDICINE CHANNEL
- AREA ADDRESSABLE COMMUNICATIONS
- PORTABLE OR MOBILE EARTH STATIONS BECOME POSSIBLE

ACTS Flight Segment



NASA

ACTS



AEROSPACE TECHNOLOGY DIRECTORATE

SPACE ELECTRONICS DIVISION



APPLICATIONS OF NEW TECHNOLOGY (CONT.)

ON-BOARD DETECTION AND SWITCHING

- RECONSTITUTED SIGNAL IMPROVES IMMUNITY TO NOISE
- MESSAGE/DATA ROUTING PERFORMED ON SPACECRAFT

APPROACH

- DEVELOP IMPROVED MODULATION AND CODING
- DEVELOP BULK DEMODULATORS (MULTI-CHANNEL DEMODULATORS)
- DEVELOP BASEBAND SWITCHING FOR INDIVIDUAL MESSAGES
- PROTOTYPE HARDWARE
- SPACE EXPERIMENTS/DEMONSTRATIONS

BENEFITS

- REDUCED POWER AND COST FOR TELEMEDICINE DATA AND VOICE MESSAGES
- MESSAGE ROUTING TO SUPPORT A LARGE NUMBER OF USERS

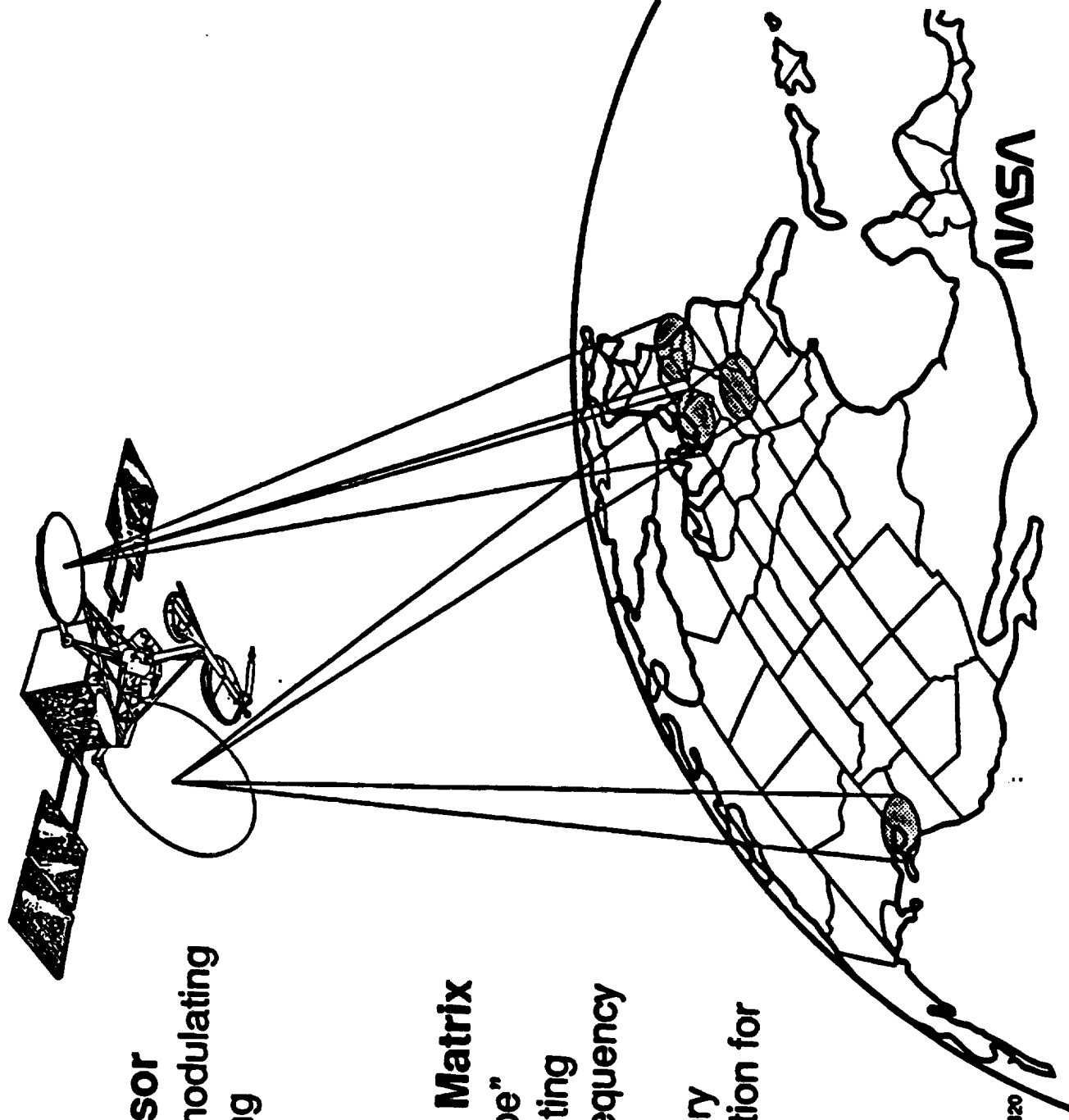
ACTS Switching and Processing Technology

Baseband Processor

- Demodulating/remodulating
- Decoding/encoding
- Routing
- Circuit switching
- Onboard memory

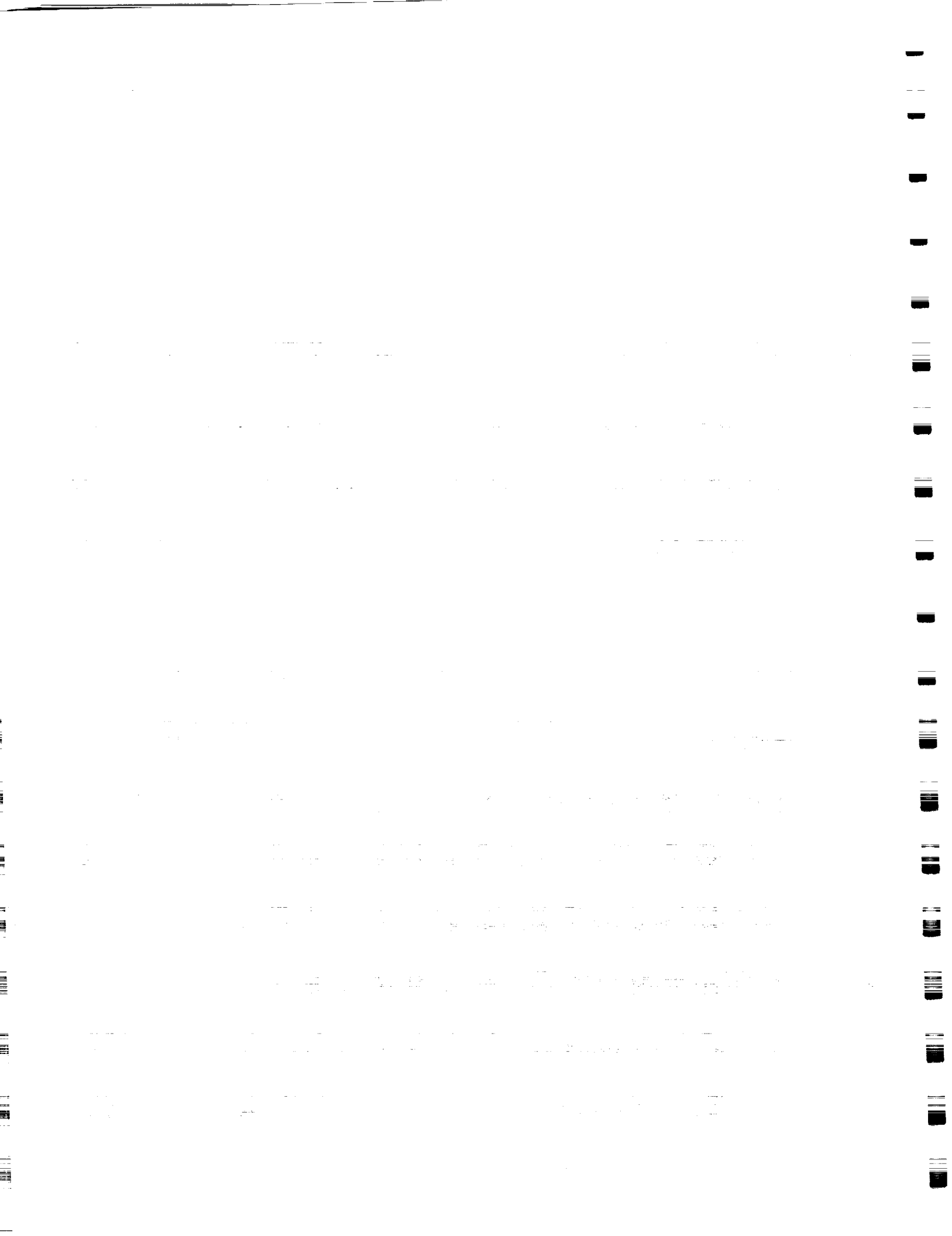
Microwave Switch Matrix

- Dynamic "Bent Pipe"
- beam-to-beam routing
- Uplink/downlink frequency translation
- No onboard memory
- Static-mode operation for continuous carriers



CD-54120

ACTS





AEROSPACE TECHNOLOGY DIRECTORATE

SPACE ELECTRONICS DIVISION



APPLICATIONS OF NEW TECHNOLOGY (CONT.)

MISCELLANEOUS TECHNOLOGY IMPROVEMENTS

- HIGH EFFICIENCY TRANSMITTERS
- AUTOMATIC TRACKING ANTENNAS FOR RECEIVING SYSTEMS
- IMPROVED PERFORMANCE SOLID STATE AMPLIFIERS

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AEROSPACE TECHNOLOGY DIRECTORATE

SPACE ELECTRONICS DIVISION



APPLICATIONS OF NEW TECHNOLOGY (CONT.)

MOBILE SATELLITE COMMUNICATIONS SYSTEMS

- UBIQUITOUS TERMINALS FOR POST-DISASTER TELEMEDICINE
- LOW EARTH ORBIT SATELLITES REQUIRE SMALLER TERMINALS

APPROACH

- COMMERCIAL SYSTEMS ALREADY PROPOSED
- DEVELOPING INFRASTRUCTURE CAN BE USED FOR TELEMEDICINE APPLICATIONS

BENEFITS

- LOW COST BY USING DEVELOPED SYSTEM
- WIDESPREAD ACCESS TO NETWORK FOR DATA, FACSIMILE, AND VOICE TRANSMISSIONS

GLOBALSTAR

GLOBALSTAR INFRASTRUCTURE

SS/L SATELLITES

**LOCAL CELLULAR
TRANSMISSION SERVICES**

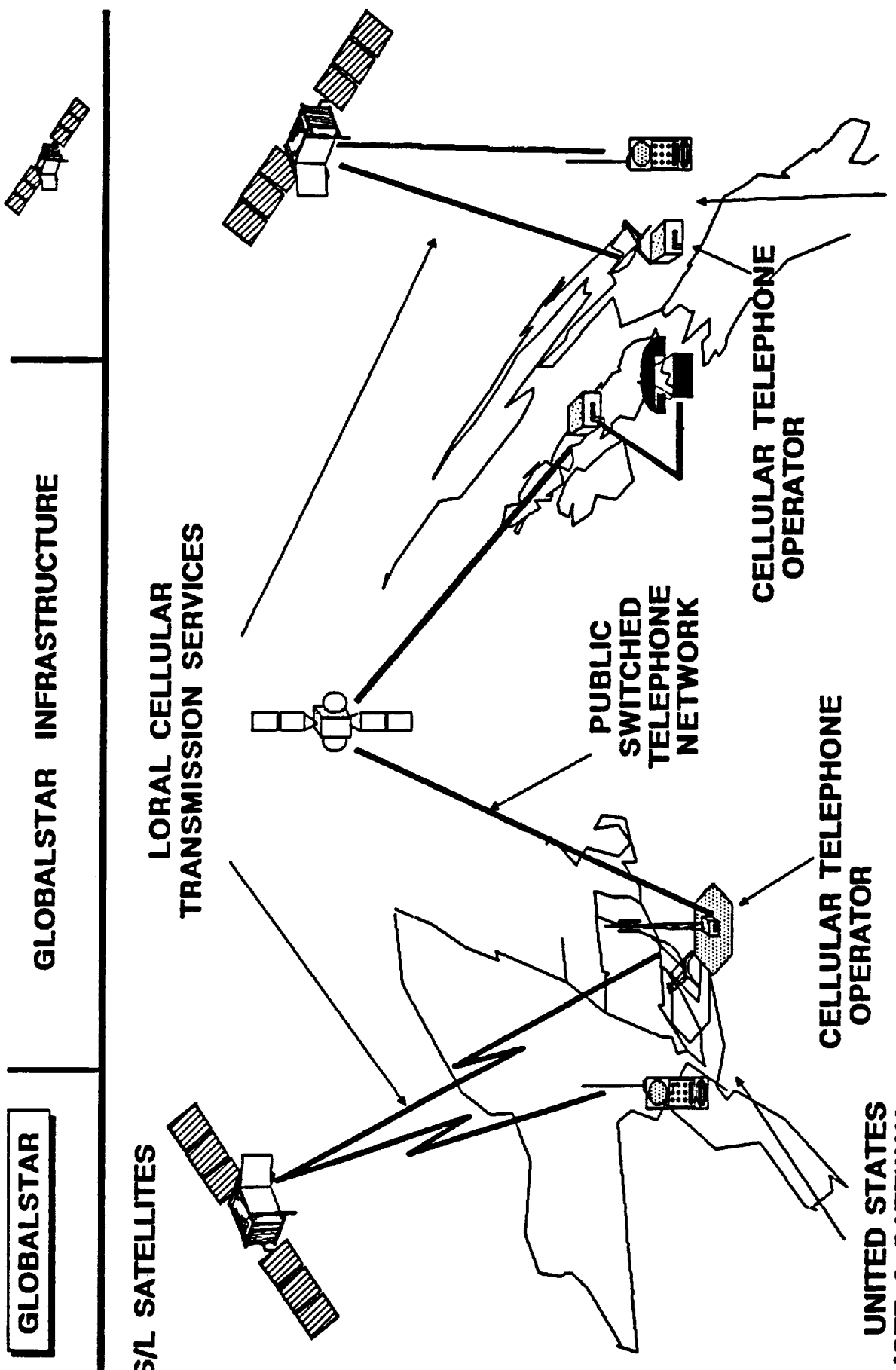
**UNITED STATES
USER & GATEWAY
EQUIPMENT**

**CELLULAR TELEPHONE
OPERATOR**

**PUBLIC
SWITCHED
TELEPHONE
NETWORK**

**CELLULAR TELEPHONE
OPERATOR**

**EUROPEAN
USER & GATEWAY
EQUIPMENT**





AEROSPACE TECHNOLOGY DIRECTORATE

SPACE ELECTRONICS DIVISION



USE OF HIGHER FREQUENCIES

- PRACTICABLE, HIGH GAIN, SPOT BEAM ANTENNAS
- ACCESS TO UNCROWDED PART OF FREQUENCY SPECTRUM
(20 GHz AND 30 GHz, FOR EXAMPLE)

APPROACH

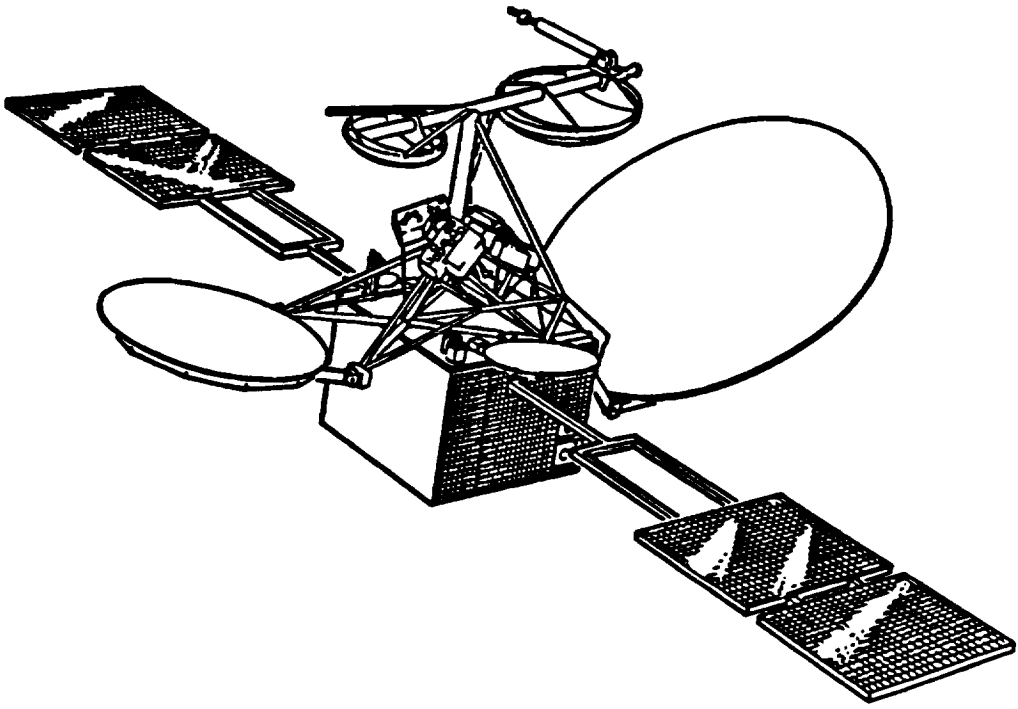
- DEVELOP TECHNOLOGIES OF ANTENNAS, ON-BOARD DETECTORS, SPACECRAFT SWITCHING, HIGH FREQUENCY COMPONENTS,
- DEVELOP AN EXPERIMENTAL SATELLITE (ACTS - 1993)
- PERFORM EXPERIMENTS TO DEMONSTRATE USE (1993-1995)

BENEFITS

- COMBINED ADVANTAGES OF TECHNOLOGIES USED
LOWER POWER
LOWER COST
MESSAGE SWITCHING

•
•
•

ACTS Spacecraft Characteristics



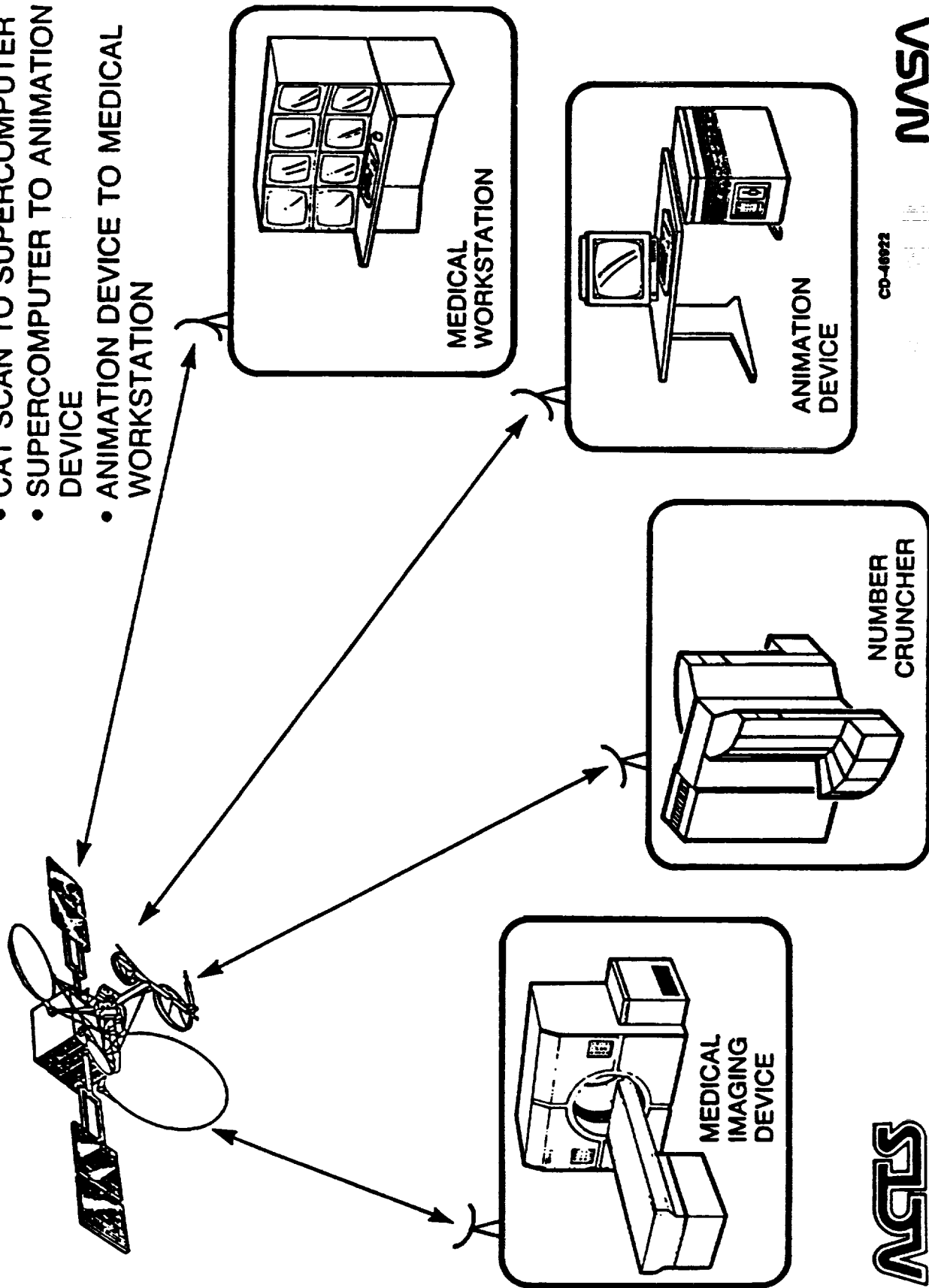
Weight:	3250 lbs (on-orbit)
Power:	1770 W BOL four panel solar array (134.5 ft ²)
Frequency bands:	Ka-band (30/20 GHz)
Payload:	Multibeam antenna, on-board processing and routing
Spacecraft pointing accuracy:	+ 0.025°
Launch date:	February 1993
Mission requirement:	2 yrs Experiment period 4+ yrs Station keeping fuel

CD-55709



"REMOTE" MEDICAL IMAGING

- CAT SCAN TO SUPERCOMPUTER
- SUPERCOMPUTER TO ANIMATION DEVICE
- ANIMATION DEVICE TO MEDICAL WORKSTATION



AGCS

CD-46922

NASA





NASA
Lewis Research Center

- **EVALUATE SATELLITE ARCHITECTURES FOR PROVIDING COMPLEMENTARY MULTICAST/BROADCAST CAPABILITY TO A BROAD-BAND ISDN BASED TERRESTRIAL NETWORK**

- **COMPATIBLE WITH PLANNED ATM PROTOCOL**
- **PROVISIONS FOR CIRCUMVENTING SATELLITE PATH DELAY**

- **ENHANCES MARKET POTENTIAL OF SATELLITE TECHNOLOGY**

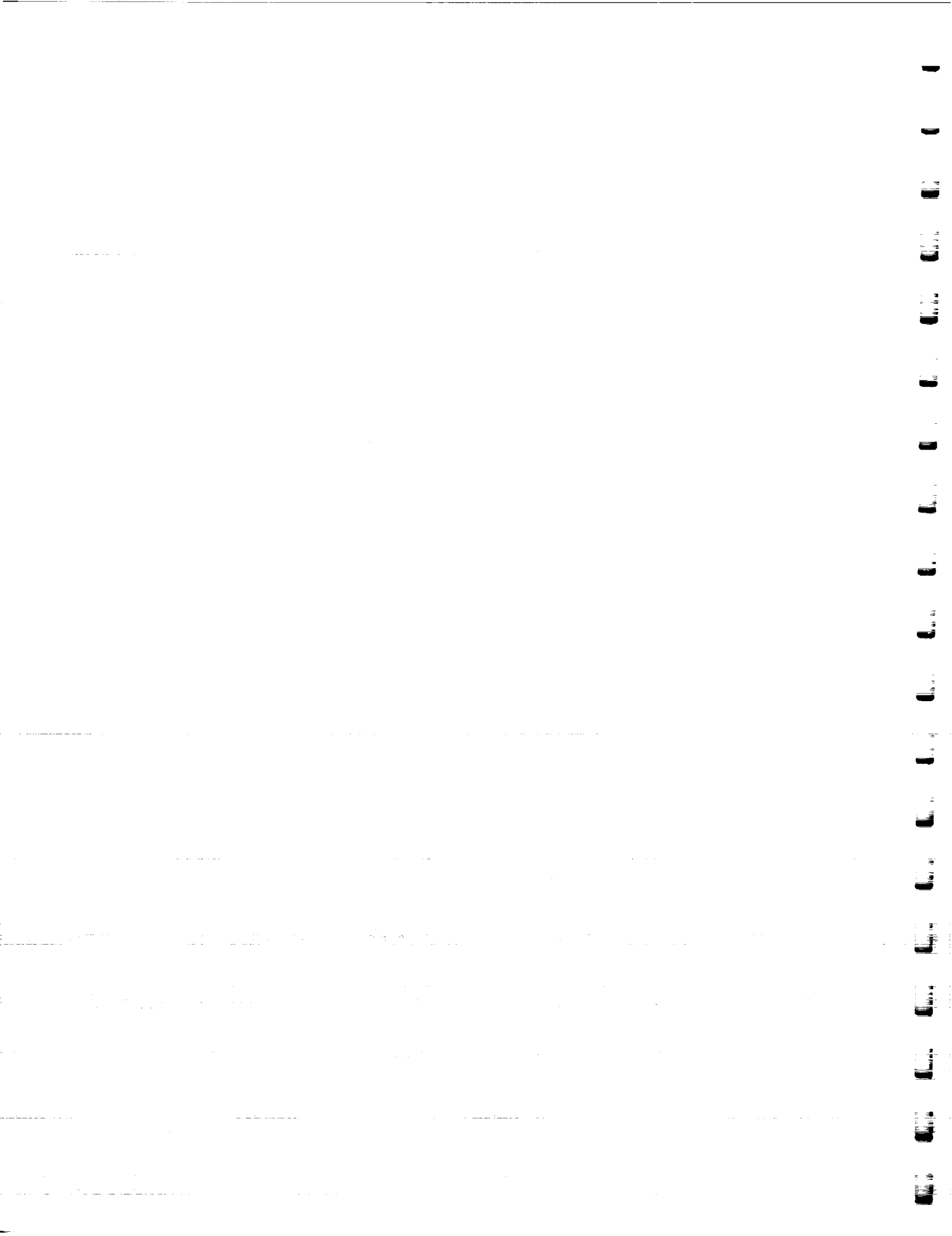
- **TAKES ADVANTAGE OF B-ISDN FEATURES TO ENHANCE SATELLITE HARDWARE EFFICIENCY AND UTILIZATION**
- **STRAIGHTFORWARD IMPLEMENTATION OF MULTICAST/BROADCAST ENHANCEMENT OF B-ISDN PROTOCOL**

- **STUDY RESULTS SUPPORT GENERAL CONCEPT**

SUMMARY

NEW TECHNOLOGY DEVELOPMENTS APPLIED TO SATELLITE COMMUNICATIONS CAN FACILITATE
TELEMEDICINE APPLICATIONS. BENEFITS FROM USING NEW TECHNOLOGY INCLUDE LOWER POWER,
SMALLER SIZE, REDUCED COST, AND GREATER AVAILABILITY IN POST DISASTER SITUATIONS.

[illegible]



Linking Medical Records to an Expert System

Frank Naeymi-Rad Ph.D.¹, David Trace M.D.¹, and Fabio De Souza Almeida M.D.²

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This presentation will be done using the IMR-Entry (Intelligent Medical Record Entry) system. IMR-Entry is a software program developed as a front-end to our diagnostic consultant software MEDAS (Medical Emergency Decision Assistance System).

MEDAS (the Medical Emergency Diagnostic Assistance System) is a diagnostic consultant system using a multimembership Bayesian design for its inference engine and relational database technology for its knowledge base maintenance. Research on MEDAS began at the University of Southern California and the Institute of Critical Care in the mid 1970's with support from NASA and NSF. The MEDAS project moved to Chicago in 1982; its current progress is due to collaboration between Illinois Institute of Technology, The Chicago Medical School, Lake Forest College and NASA at KSC. We acknowledge the support provided by Dr. Daniel Woodard, Dr. Paul Buchanan and Dr. Ronald White.

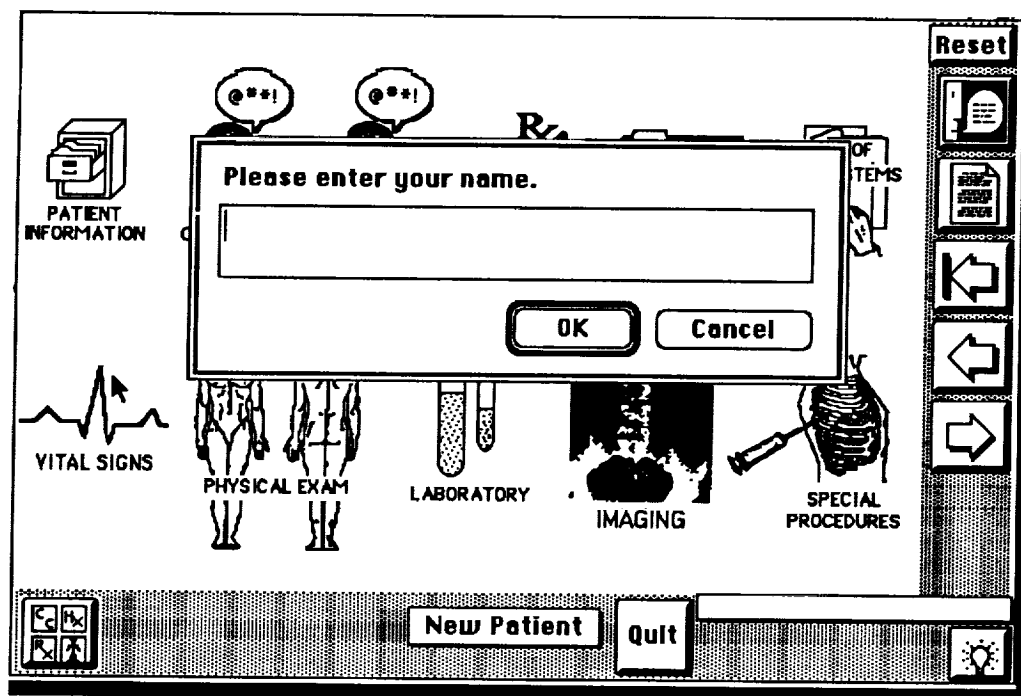
MEDAS DISORDER PATTERN

Dec. 01, 1988 8:45:36 AM		<<DISORDER PATTERN SYSTEM>> Developed by UHS/CMS Computer Center		Screen No. MED S20		
Disorder #12 (OR STOP)		Name: PULMONARY THROMBOEMBOLISM Category: RESPIRATORY Date Created: 02/13/87 Prevalence Rate: 0.07		# OFF: 75 SORT ID: Post+		
	F#	Feature Name	P	Pbar	Post. When +	Post When -
1)	738	V/P LUNG SCAN: MMATCH VENT & (+) IPG	.949	.050	.588	.004
2)	622	ANGIO: PULMONARY PERFUSION DEFECT	.899	.050	.575	.008
3)	750	ECG - S1-Q3-T3 PATTERN	.100	.009	.455	.064
4)	643	CXR: PULMONARY INFILTRATE UNILATERAL	.200	.029	.342	.058
5)	174	S/O DEEP VEIN THROMBOPHLEBITIS	.300	.100	.184	.055
6)	338	M.S. DEEP MUSCULAR TENDERNESS	.300	.100	.184	.055
7)	485	PVS PITTING EDEMA UNILATERAL	.300	.100	.184	.055
8)	630	V/P LUNG SCAN: EMBOLISM	.600	.200	.184	.036
9)	747	H/O DEEP VEIN THROMBOSIS	.300	.100	.184	.055
10)	638	CXR: ATELECTASIS	.050	.019	.165	.068
11)	1179	CXR PLEURAL EFFUSION UNILATERAL	.300	.119	.159	.056
1) Look 2) Create 3) Delete 4) Change prob 5) Sort option 6) Exit						
Please select 1, 2, 3, 4, 5, or 6 >						

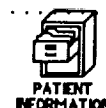
This screen demonstrates the disorder pattern for Pulmonary Thromboembolism. Since the purpose of an expert system is to derive a hypothesis, its communication vocabulary is limited to features used by its knowledge base. Recognizing this problem our team in Chicago, for the last five years, has been working on the development of a comprehensive problem based medical record entry system which could handshake with an expert system while creating an electronic medical record at the same time.

IMR-E is a computer based patient record that serves as a "front end" to the expert system MEDAS. IMR-E is a graphically oriented comprehensive medical record. We demonstrate the program's major components in the following article:

IMR-Entry requires the provider to identify themselves before he or she is allowed to use the system. This Identification is used to tag all of the data created for the given session by the entry person's identification.



The following screen will appear by clicking on the Patient Information icon:




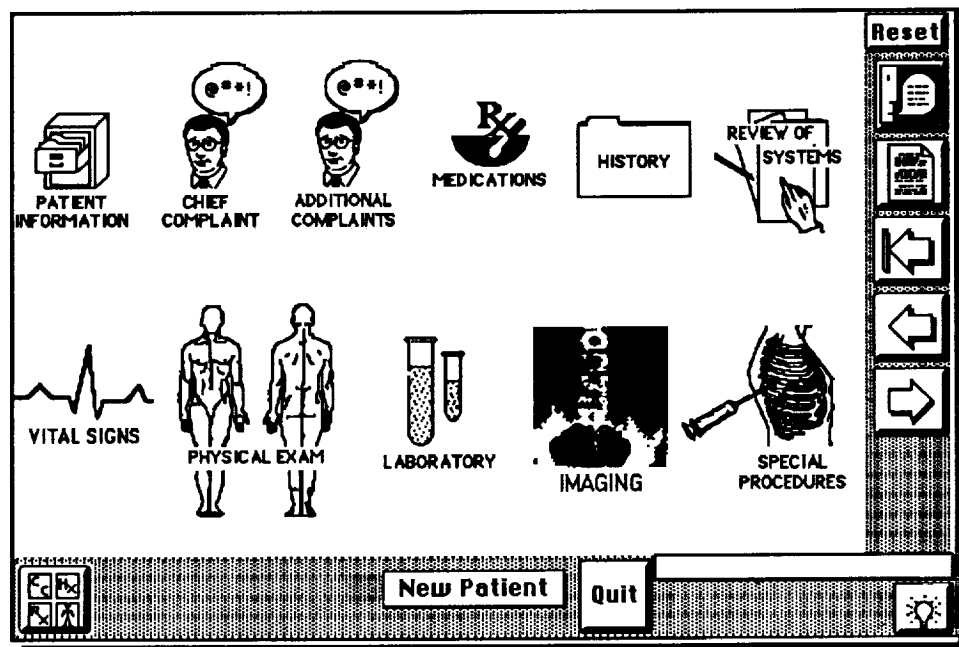
Patient Identification

Last Name		First Name	
Naeymi-Rad		Frank	
Social Security #	Birthdate	Age	
1111-44-3333	10/10/50	41	
Sex	Race	Status	
male female	white black hispanic asian	single <u>married</u> divorced widowed	


Quit

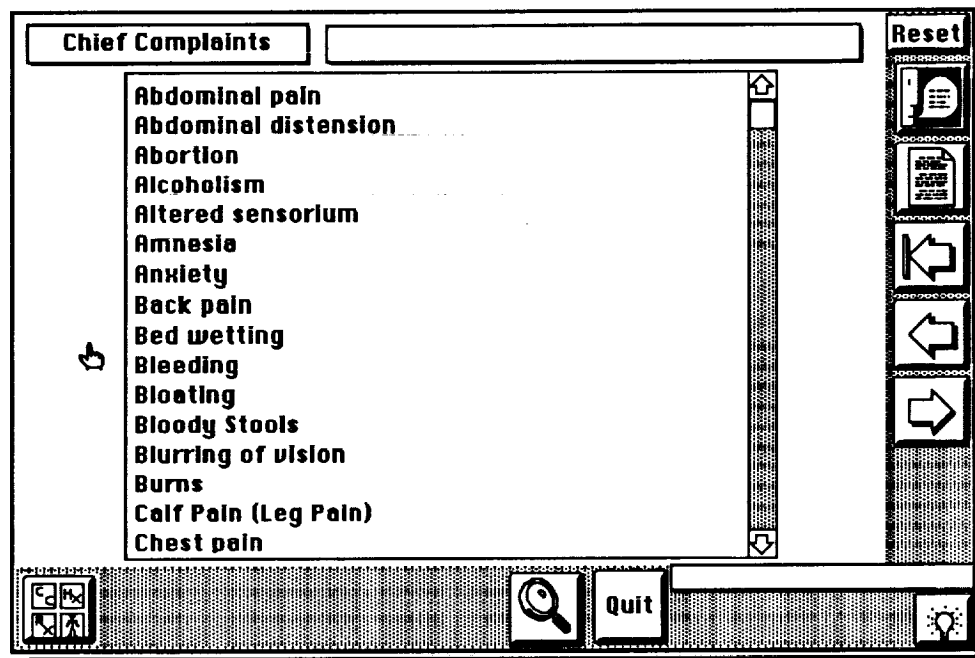
The patient selection screen can be integrated with any in-place demographics screen to eliminate the duplication of entry.

By clicking on the icon  the user will return to the following screen.



As you can see this is comprehensive and covers all of the sections for the physician's entry. The navigational icons were designed to aid the physician at each step of entry.

By clicking on the icon  **CHIEF COMPLAINT**, the following screen appears:



There are 95 complete complaint programs. Each program allows the physician to custom create a paragraph for a given complaint by using the computer mouse. Each program manages between 20 to 50 objects which are displayed on 3 to 5 screens.

This is the first screen for Abdominal Pain Chief Complaint. We can select the appropriate options by simply clicking on them.

Abdominal Pain

Onset
acute
sudden
gradual
variable

Duration
12 minutes
hours
days
weeks
months
years

Pattern
intermittent
persistent
episodic


Course
increasing
decreasing
constant
recurrent

Location
right upper quadrant
left upper quadrant
epigastrium
periumbellical area
right lower quadrant
left lower quadrant
suprapubic area

Radiation
left shoulder
back
left flank
right flank
epigastrium
right upper quadrant
left upper quadrant

Reset

Atypical episode lasts how long?

By clicking on the  we get the second screen for Abdominal Pain.

Abdominal Pain

Aggravated By
meals (2 to 4 hours after eating)
lying down
coughing
breathing
standing
walking

Relieved By
nothing
antacids
eating
fasting
vomiting
belching


Characterized As
burning
sharp
stabbing
crampy
colicky
a dull ache
a pressure sensation

Severity
mild
moderate
severe

Previous Evaluations
barium enema
upper gastrointestinal X-ray
proctoscopy

Reset

Atypical episode lasts how long?


We can review text generated to this point by clicking on the icon .

Abdominal Pain	
Aggravated By nothing meals (1/2 to 1 hour after eating) meals (2 to 4 hours after eating)	Relieved By <u>nothing</u> antacids eating
<p>The onset of the abdominal pain has been sudden and has been occurring for 12 hours. The pattern of the abdominal pain has been persistent. It's course has been Increasing. The abdominal pain is located in the right lower quadrant with radiation to the left flank and left lower quadrant. It is aggravated by coughing, standing and walking while relief is obtained by nothing. The abdominal pain is characterized as sharp and stabbing. The severity of the</p>	
cramps colicky a dull ache a pressure sensation	Previous Evaluations barium enema upper gastrointestinal X-ray proctoscopy

OK

Reset

Review icon: a hand pointing to a document.

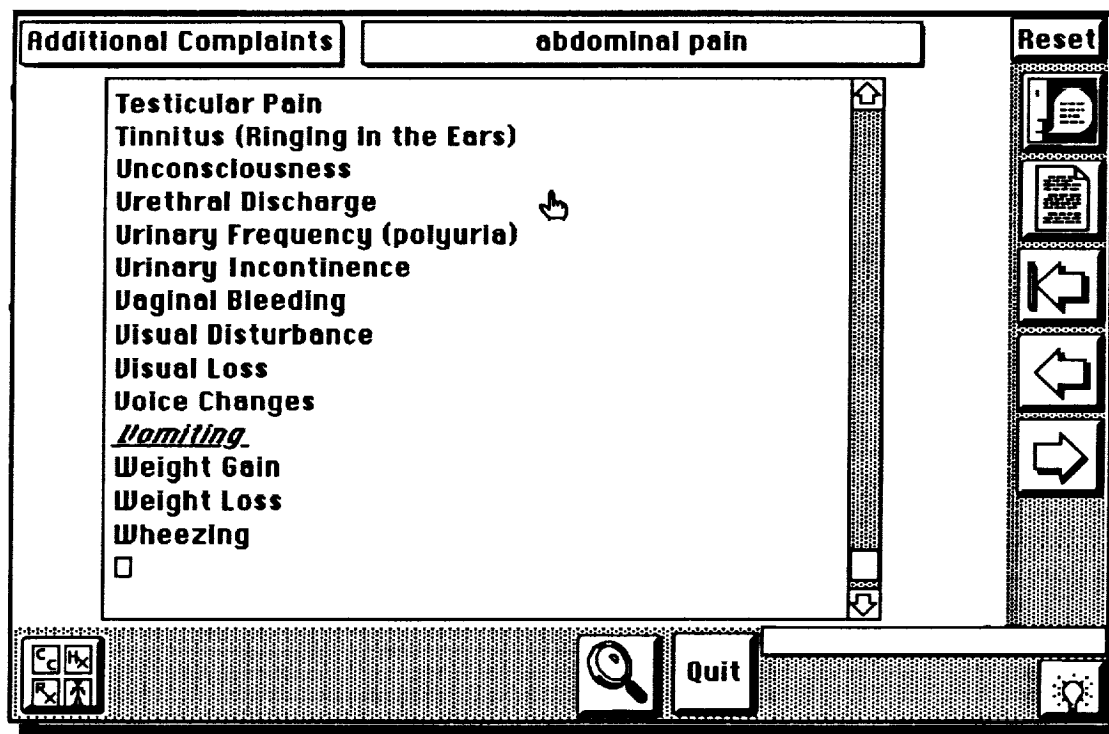
The last screen for this complaint will appear by clicking on the icon .

Abdominal Pain	
Associated With chest pain constipation dark urine diarrhea dysuria <u>fever</u> heartburn hematemesis hematuria jaundice melena <u>nausea</u> passing worms pica use of alcohol	Not Associated With abdominal distension amenorrhea anorexia bloating bloody stools bone pain bulky stools chest pain constipation dark urine diarrhea dysuria fever heartburn hematemesis

Reset

Next icon: a right-pointing arrow.




When we continue clicking on the  we move to the Additional Complaints Screen.

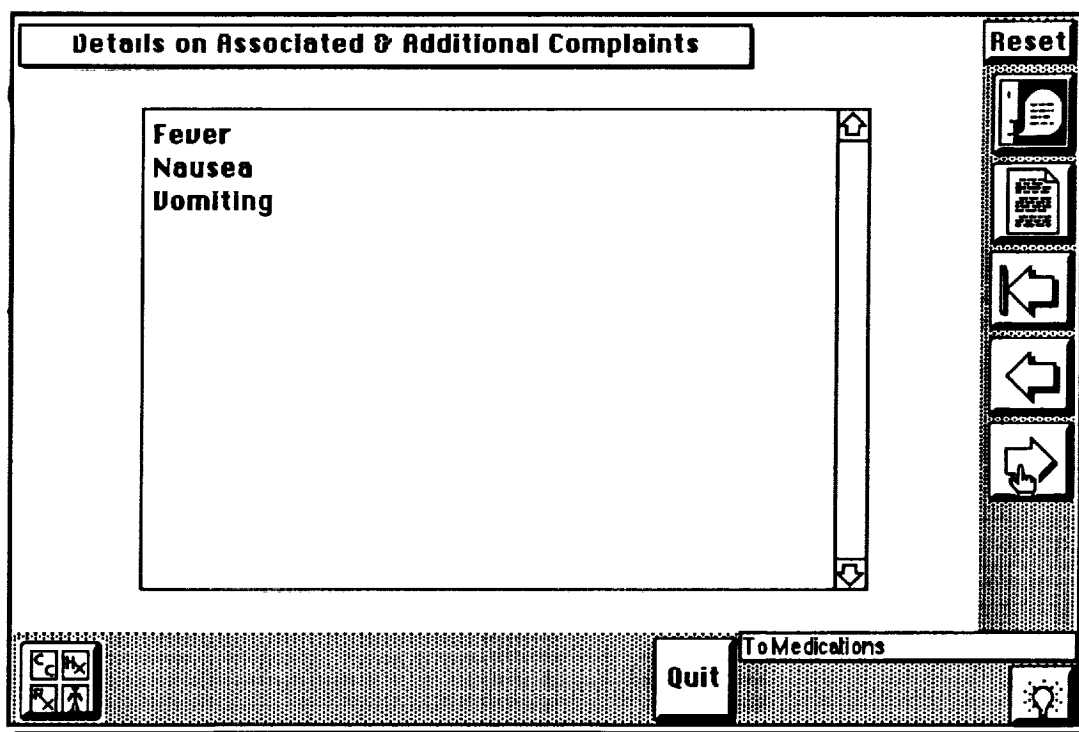


Additional Complaints abdominal pain **Reset**

- Testicular Pain
- Tinnitus (Ringing in the Ears)
- Unconsciousness
- Urethral Discharge
- Urinary Frequency (polyuria)
- Urinary Incontinence
- Vaginal Bleeding
- Visual Disturbance
- Visual Loss
- Voice Changes
- Vomiting
- Weight Gain
- Weight Loss
- Wheezing




☐

  **Quit** 




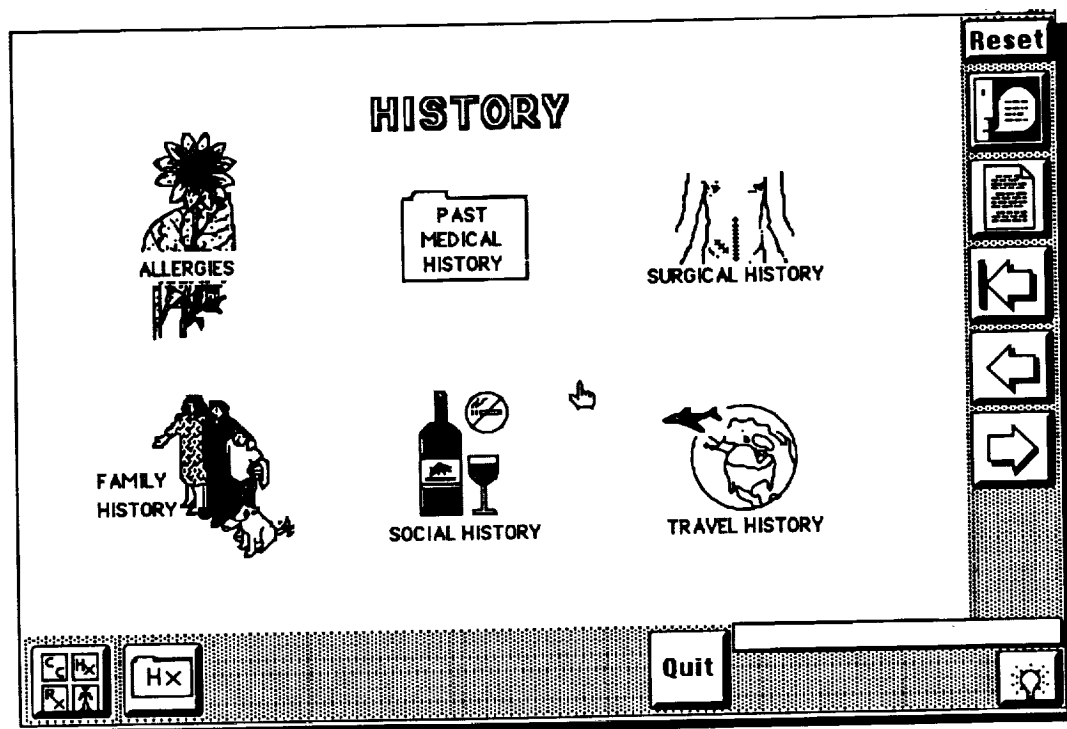
Details on Associated & Additional Complaints **Reset**

- Fever
- Nausea
- Vomiting

  **Quit** **To Medications** 

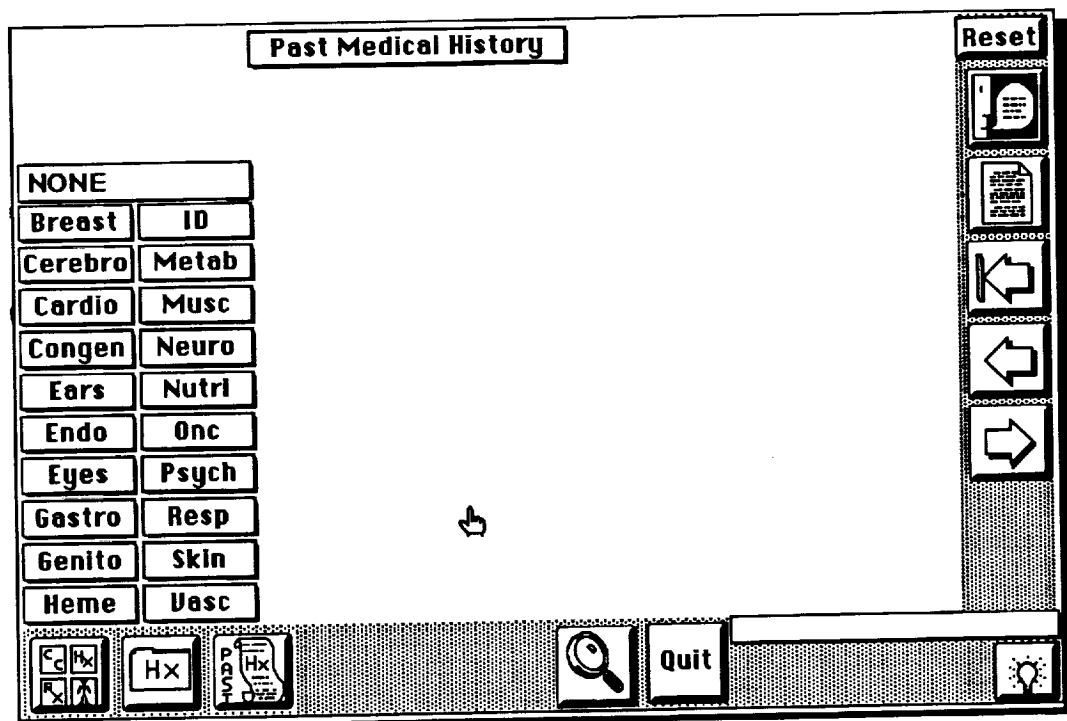
After selecting additional complaints, the system displays all the appropriate complaints that it has programmed for you. We could describe these complaints in more detail.


By selecting HISTORY folder  we can enter all of the history information.



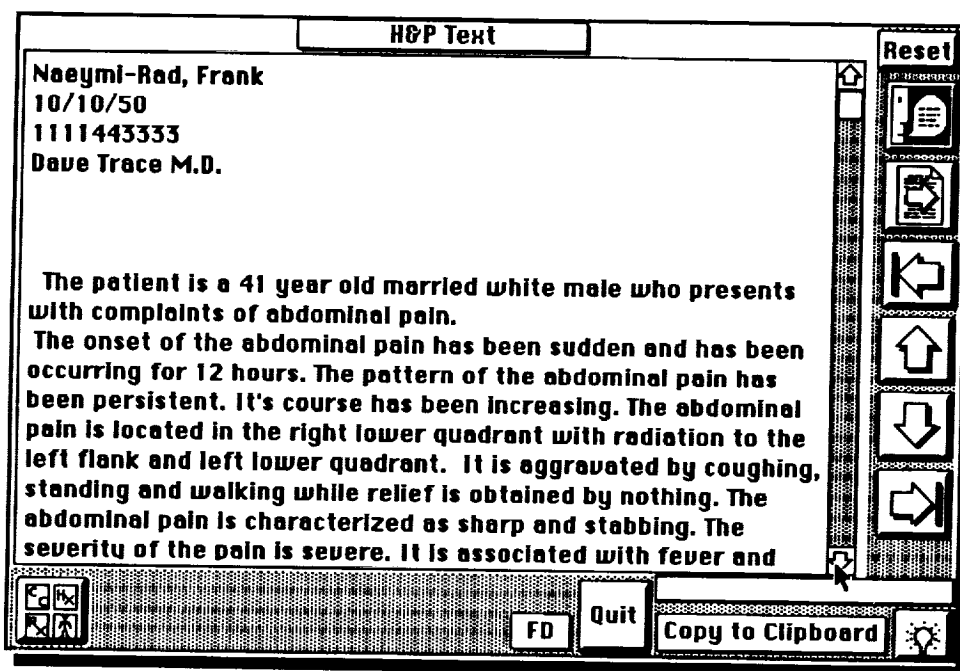
We must note that the Travel History is incomplete since does not include space travel history.

By selecting the PAST MEDICAL HISTORY Folder  we get to the next screen.




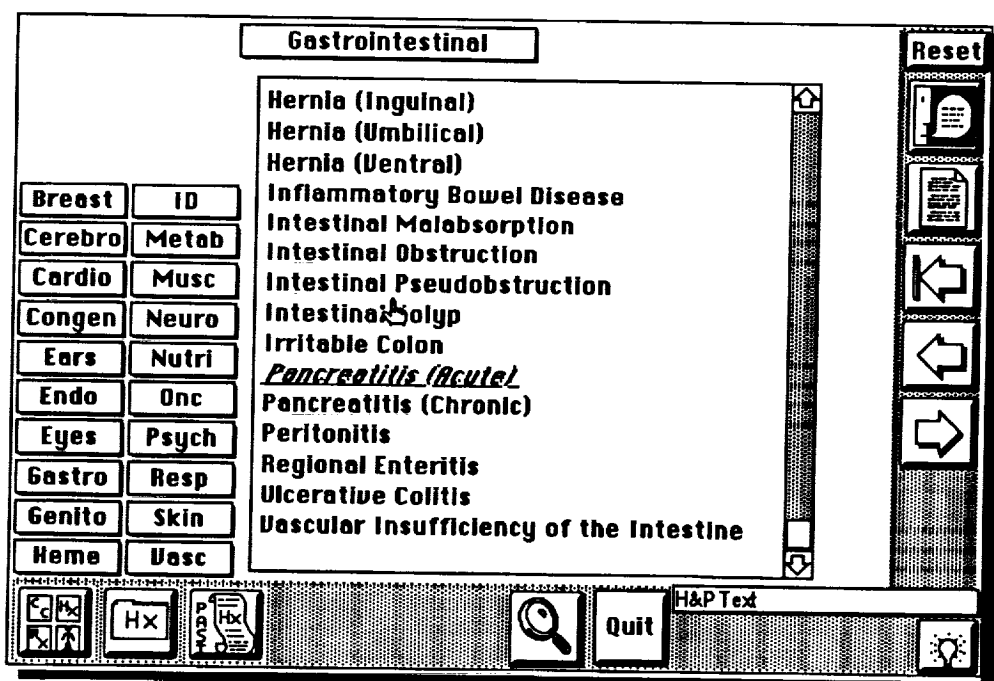
Please note: as the mouse  moves over the Icons, the dialog window on the lower right displays the function of the icon.


By clicking the text  icon system displays the current status of the final electronic report.

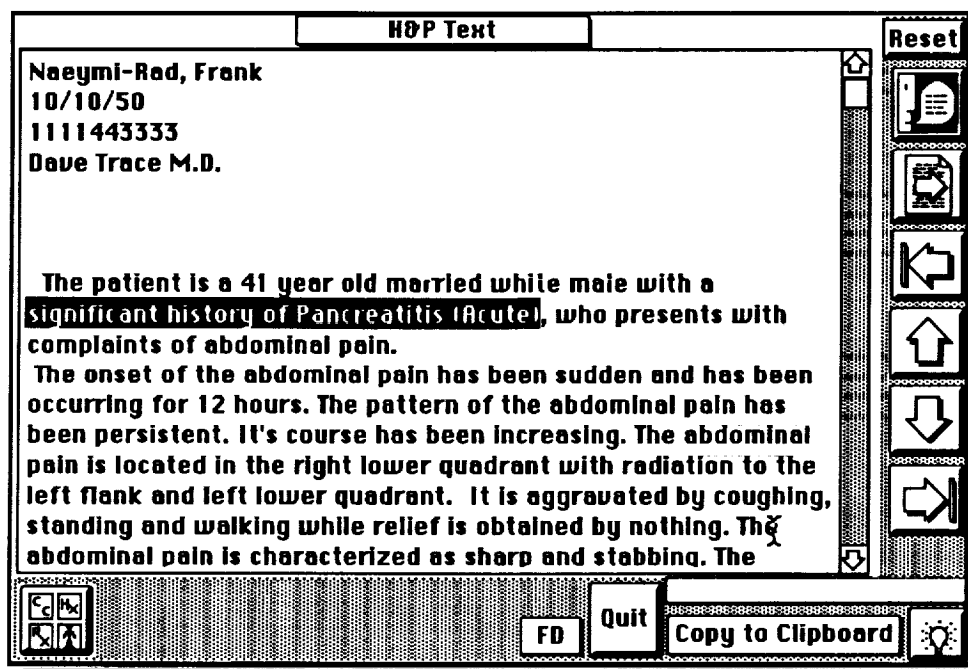


Note: the first paragraph does not have any information about significant past medical or surgical history.

We can go back to where the report generation was launched from by clicking this  icon. by selecting the Gastrointestinal section and identifying the history to the system as significant to the present illness.



When clicking the text  icon, the system displays the current status of the final electronic report with the significant history within the first paragraph.



HOP Text


Naeymi-Rad, Frank
10/10/50
1111443333
Dave Trace M.D.

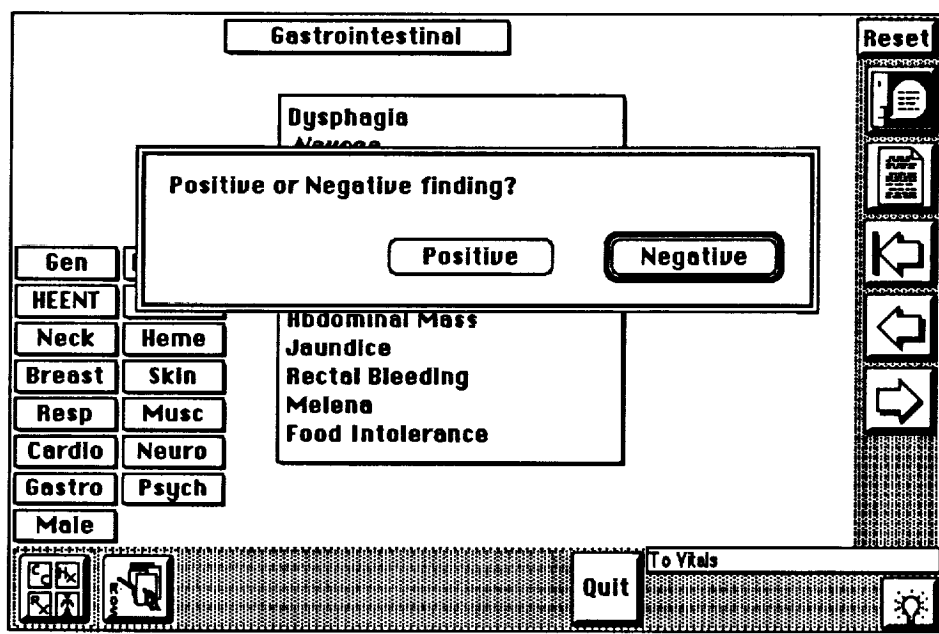
The patient is a 41 year old married white male with a significant history of Pancreatitis (Acute), who presents with complaints of abdominal pain.

The onset of the abdominal pain has been sudden and has been occurring for 12 hours. The pattern of the abdominal pain has been persistent. It's course has been increasing. The abdominal pain is located in the right lower quadrant with radiation to the left flank and left lower quadrant. It is aggravated by coughing, standing and walking while relief is obtained by nothing. The abdominal pain is characterized as sharp and stabbing. The

FD Quit Copy to Clipboard

For the purpose of time, we will return to the first screen and show you other important features needed for a complete electronic medical record.

The next screen is the result of clicking on the REVIEW OF SYSTEM  icon from the main screen. When the selections are made, the system requests the user to respond to the Positive or Negative of the given finding. This insures that significant negatives are entered into the system since the MEDAS expert system uses the negative of the finding as well as the positive.



Gastrointestinal

Dysphagia

Positive or Negative finding?

Positive Negative

Gen HEENT Neck Heme Abdominal Mass
Breast Skin Jaundice
Resp Musc Rectal Bleeding
Cardio Neuro Melena
Gastro Psych Food Intolerance
Male

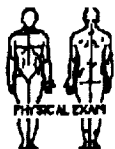
Quit To Vitals

The next screen is the result of clicking on the VITAL SIGN  icon from the main screen.

Vitals

<i>Supine</i>		<i>Standing</i>		
Systolic BP	<input type="text" value="120"/>	Systolic BP	<input type="text"/>	Resp Rate <input type="text" value="22"/>
Diastolic BP	<input type="text" value="80"/>	Diastolic BP	<input type="text"/>	Temp <input type="text" value="102"/>
Heart Rate	<input type="text" value="88"/>	Heart Rate	<input type="text"/>	Weight <input type="text" value="170"/>
				Height <input type="text"/>

Respiration
 Tachypnea (rapid shallow breathing)
 Hyperventilation
 Bradypnea
 Cheyne-Stokes breathing
 Ataxic breathing
 Sighing respiration
 Obstructive breathing












The next screen is the result of clicking on The Physical Exam  icon from the main screen.



Physical Exam






	Normal	Normal	Not		Normal	Normal	Not		Normal	Normal	Not
	Except	Except	Examined		Except	Except	Examined		Except	Except	Examined
GENERAL	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	RECTAL	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
SKIN	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	VASC	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

There are three options for each selection: Normal, Normal Except, and Not Examined. Not Examined will print "not examined" on the report. The Normal will automatically print the significant normal on the report.

Physical Exam

	Normal	Normal Except	Not Examined		Normal	Normal Except	Not Examined		Normal	Normal Except	Not Examined
GENERAL	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	RECTAL	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
SKIN	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	VASC	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The next screen demonstrate the output by our selection. The HEET was selected as normal. Please note that the object that generates the significant normal can be modified to print more, or less information on the report.

H&P Text

+ Nausea
 - Abdominal Mass

I



PHYSICAL EXAM








VITALS
 Supine BP 120/80 Supine HR 88 Temp 102F RR 22 Wt 170


GENERAL Not Examined

SKIN Not Examined












HEENT
 AT, NC, PERRLA, EOMI, Fundi w/o exudates or hemorrhages,
 discs sharp, Ears B/L clear, Oropharynx & sinuses clear.







To select "normal except" for the abdominal exam, click on the Abdomen  icon.






Physical Exam

	Normal	Normal Except	Not Examined		Normal	Normal Except	Not Examined		Normal	Normal Except	Not Examined
GENERAL	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	RECTAL	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
SKIN	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	VASC	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Quit



Reset







This action will start the abdominal exam program (the following screen). Each Physical Exam has its own unique options. In this exam the options are Inspection, Percussion, and Auscultation.




Abdominal Exam

Inspection

Palpation / Percussion


Auscultation








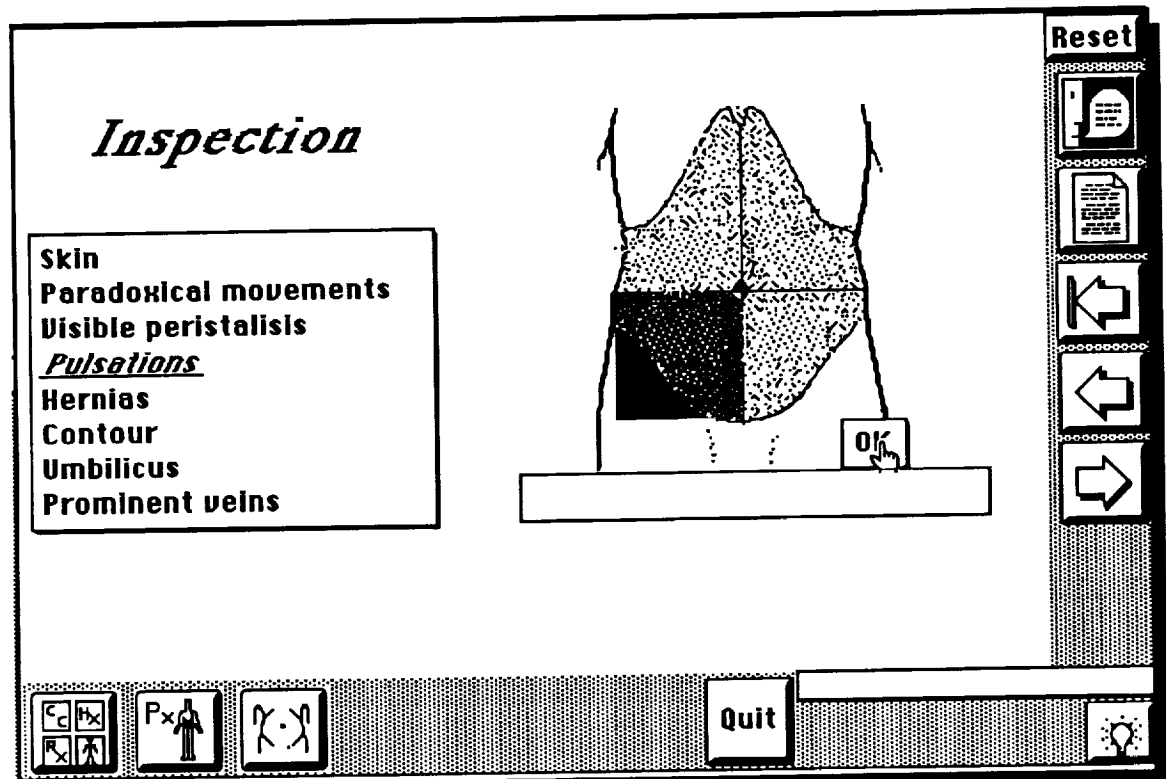
Quit

Physical Exam Menu



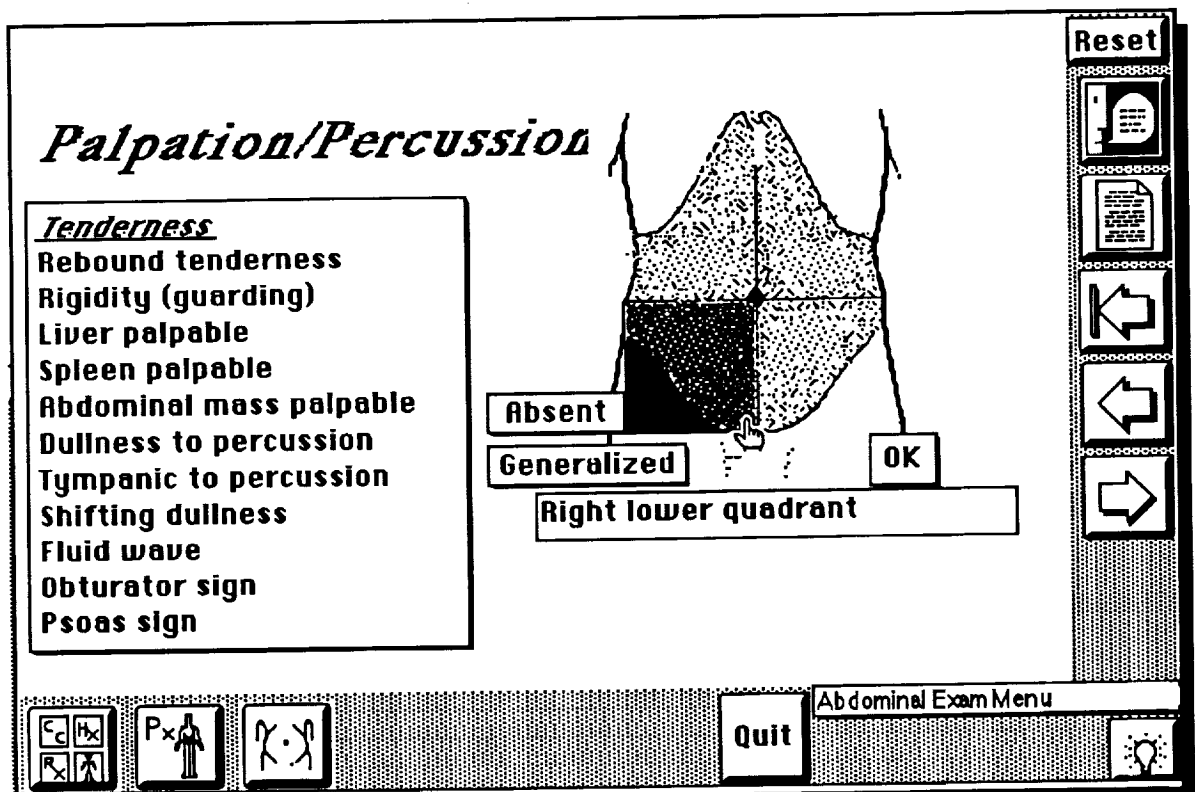
Reset






When selecting "Inspection" the screen controlling the Inspection objects is launched.

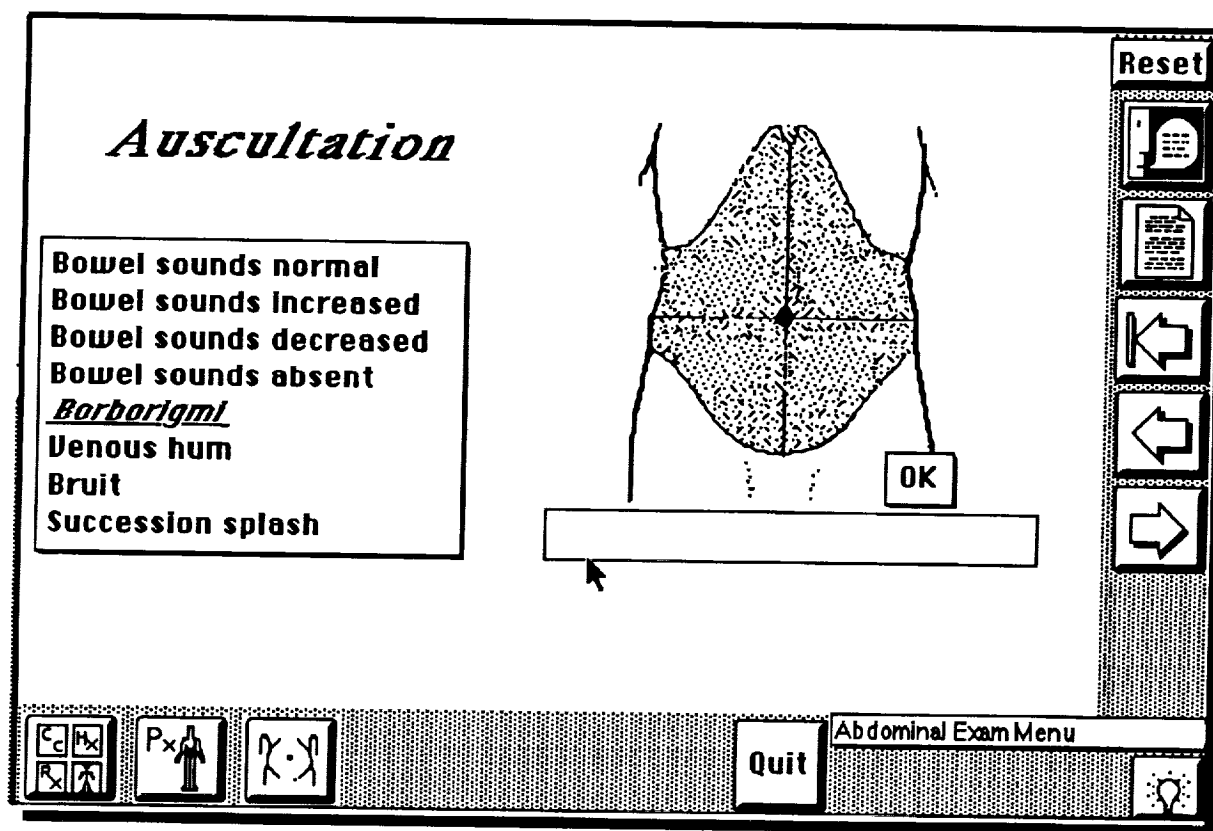


Each of the screens within the physical exam module manage 50 to 300 unique objects.

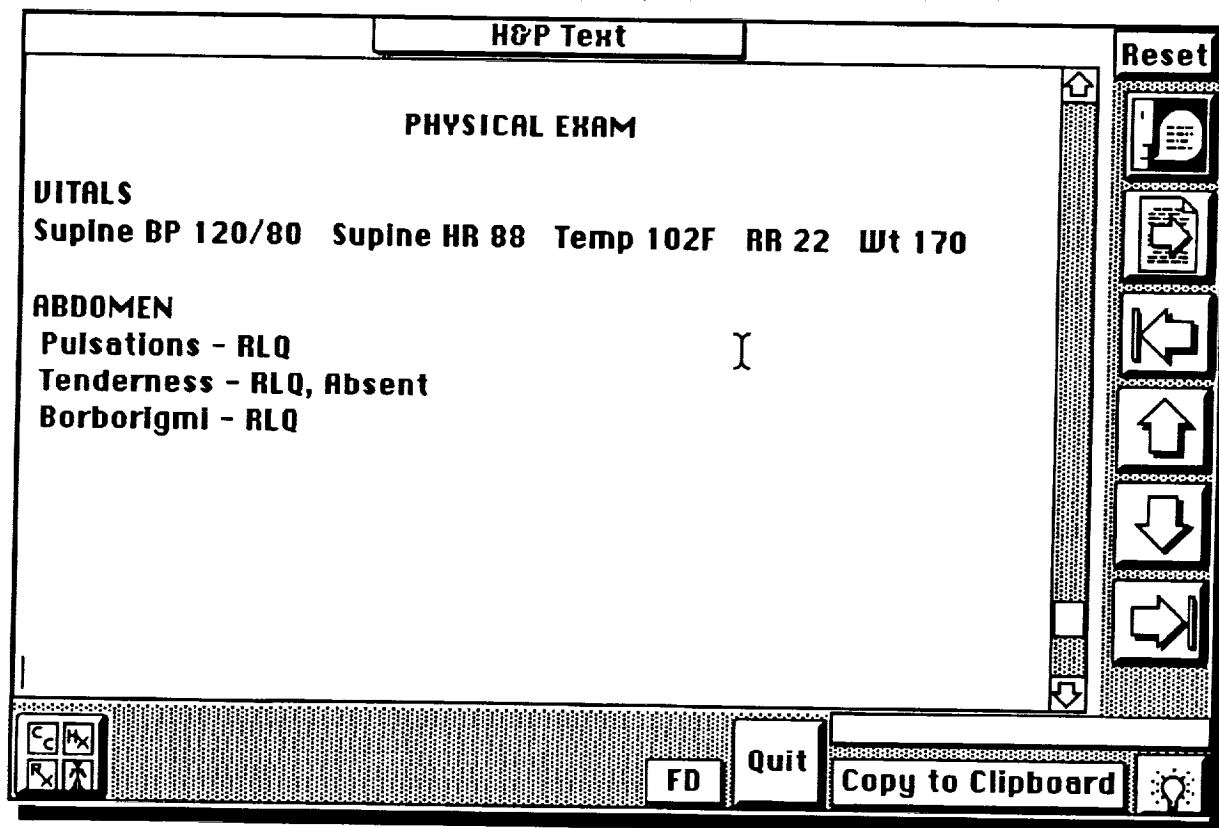
The following is an example of the "Percussion" screen.



The following is an example of the "Auscultation" screen.



This next screen demonstrates the output generated by the physical exam.

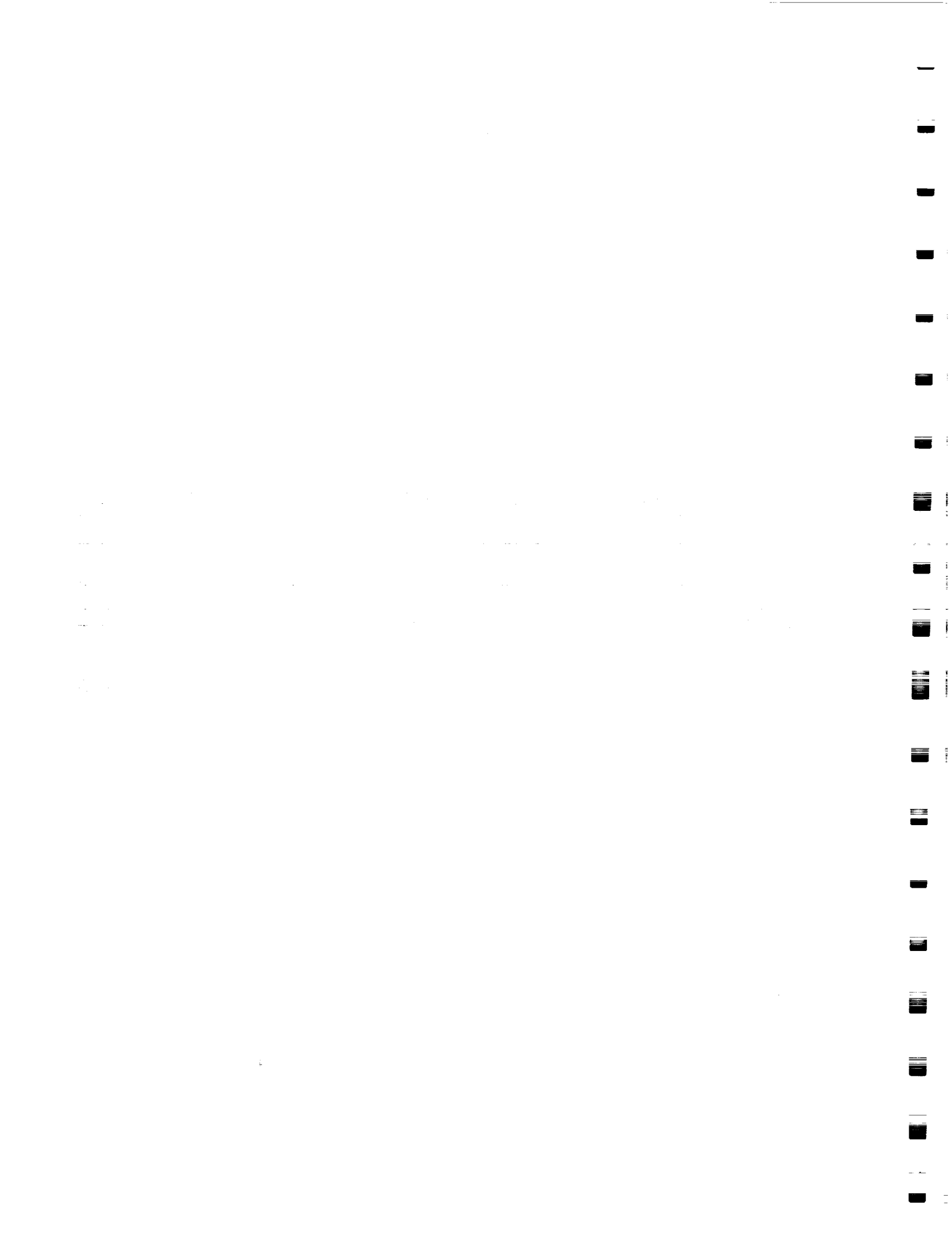


When clicking on the FD button on the lower part of the screen, the system generates the term dictionary that can be used to communicate to the expert system.

back	Medas Dictionary
1111443333	
Frank	
Naeymi-Rad	
SEX.1+.male	
RACE.1+.white	
Status.2+.married	
CC.1+.Abdominal pain	
CCAC.37+.fever	
CCAC.56+.nausea	
CCAC.82+.Vomiting	
CC.1O2+.abdominal pain onset sudden	
CC.1D2+.abdominal pain duration hours	
CC.1P2+.abdominal pain pattern persistent	
CC.1C1+.abdominal pain course increasing	
CC.1L5+.abdominal pain location right lower quadrant	
CC.1R5+.abdominal pain radiation left flank	
CC.1R12+.abdominal pain radiation left lower quadrant	
CC.1A5+.abdominal pain aggravated by coughing	
CC.1A7+.abdominal pain aggravated by standing	
CC.1A8+.abdominal pain aggravated by walking	
CC.1RE1+.abdominal pain relieved by nothing	
CC.1CH2+.abdominal pain characterized as sharp	
CC.1CH3+.abdominal pain characterized as stabbing	
CC.1AS13+.abdominal pain associated with fever	
CC.1AS19+.abdominal pain associated with nausea	
MEDS.97+.BENZATHINE PENICILLIN G.97	
PMHCY.38+.Cardiovascular Pulmonary Hypertension	

As you can see, the system generates many terms for this very simple exam. The current system generates over 65,000 terms while the current MEDAS data dictionary has only 1,750 of these terms.

In conclusion we have demonstrated the need of an independent and complete front-end to a medical expert system.



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Commercial Applications of Telemedicine

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Telemedicine Systems Corporation was established in 1976 and is a private commercial supplier of telemedicine systems. These systems are various combinations of communications and diagnostic technology, designed to allow the delivery of health care services to remote facilities. The technology and the health care services are paid for by the remote facilities, such as prisons.

THE COMMERCIAL DELIVERY OF REMOTE HEALTH CARE

Bridging distances between the sources of health care and the users of this care is becoming more common through the use of technology. However, for this technology to become widely used it is important that it be paid for in the context of the services that it delivers.

Telemedicine systems provide technology for the delivery of health care that allows prisons to purchase quality health care services and to save in security and transportation costs. This makes the use of the technology economically feasible.

The success of telemedicine in the private sector will depend on the comparative pricing and added value advantages of delivering health care services using communications technology.

EXAMPLES OF ECONOMIC AND VALUE ADDED THEORIES AFFECTING THE SUCCESSFUL COMMERCIAL APPLICATION OF TELEMEDICINE

The following are observations of factors which must be considered for a successful communication system and are based on experience in the successful commercial operation of a telemedicine system over the last 5 years.

In all situations the objective is to maximize the use of resources at the remote site, to provide the highest quality of care possible and to minimize the need for additional resources or the transportation of the patient or the consultant.

— If information can be gathered and communicated, a diagnosis can be made.

If substantive test results can be supplied at the time of consultation, the specialist need only interpret the results to make a diagnosis. If, however, further tests are required or the results are inconclusive, the patient must be referred outside if the necessary equipment to perform tests is

not available at that site. Therefore, if the appropriate information is available, the job can be done completely utilizing the telemedicine system.

In cases where information or capabilities are not, or are, available in a remote location, alternative modalities of care can be selected. For example, in one case the physician at a remote site recommended that a patient be referred outside for arthroscopy of a painful right knee. The specialist instead recommended the use of anti-inflammatory agents, which is a different modality of care utilizing the resources available at the remote site and removed the need for outside referral. In this type of instance, physical therapy was also recommended in place of outside referral for surgical procedures. In either situation value is added to the remote site.

In the instance of prescription of medication, the specialist can often determine an adjustment in dosage according to the symptoms presented over the system. This is especially evident in fields such as dermatology, which has a referral rate as low as 0 percent. The specialist can view the patient, discuss the symptoms, and adjust medication.

This means that the physician over the telemedicine system is able to not only diagnose the condition of the patient, but also to evaluate the resources at the remote site and make recommendations based upon those resources.

— The physician must be able to assess the needs of the patient and also the resources on hand, determine an alternative combination of the resources on hand, or refer to a place that has more extensive resources. In any case the value added must be equal to the cost of the services provided and the cost of the communications technology.

For example, the use of the Telemedicine System results in reduction of unnecessary referrals caused by an exaggerated analysis of the situation by the physician or patient on site, which is better interpreted by the physician off site. This results in a reversal in the referral pattern, which is normally associated with the use of specialists. In this application, the referral pattern is a reduction in the amount of referrals.

— The use of the telemedicine system results in a more effective utilization of existing information and service resources.

The specialists' consultation does not necessarily require referral, but often results in more information being derived from the same data, resulting in a maximization of the utilization of existing resources and thereby opening up alternative modalities of care and allowing the consideration of their associated costs, and the utilization of existing resources.

— Multiple specialists from the same source allow immediate diagnosis of interactive treatment, reducing negative outcomes and associated costs.

— The efficacy of the system is enhanced when of all patients seen over telemedicine, only those patients actually in need of physical contact are referred.

— The type of provider and type of care that is feasible over the telemedicine system are directly related to categories of care that can be billed and are allowable under existing payment plans.

Commercial applications require economic feasibility, derived from a source of payment. For example, in the United States today, the primary source of payment is through insurance companies, government agencies and programs, managed care groups, and fee for service.

For example, remote and on site professional levels must relate to available payment schedules, the most common of which at this time would be payment to specialist consultants or primary care consultants, or the consultant level associated with allowable charges to the payer that exist in the given situation.

— The type of payment agreement and type of payer determines the telemedicine systems services that are economically feasible.

— Services that can be sold to actual consumers or brokers offer the best opportunity for innovative commercial opportunities.

ECONOMIC EFFECTIVENESS OF TELEMEDICINE SYSTEM CONSULTS BY SPECIALTY: THE BOTTOM LINE

After identification of the reasons for referral from a remote site for each specialty, it is possible to identify those specialties that can best utilize telemedicine. The following considers each specialty from statistical information obtained from the use of the telemedicine system.

Neurology: There was a 15 percent outside referral rate within the specialty of neurology, outside referrals for diagnostic imaging.

Cardiology: This specialty had a 32 percent outside referral rate, for noninvasive and invasive diagnostic testing, and surgery.

Urology: A 26 percent outside referral rate for IVP, nephrogram, ultrasound, removal of kidney stones, cystogram, transurethral biopsy of prostate.

Endocrinology: A 10 percent referral rate for diagnostic testing.

Nephrology: No outside referrals.

Dermatology: No outside referrals.

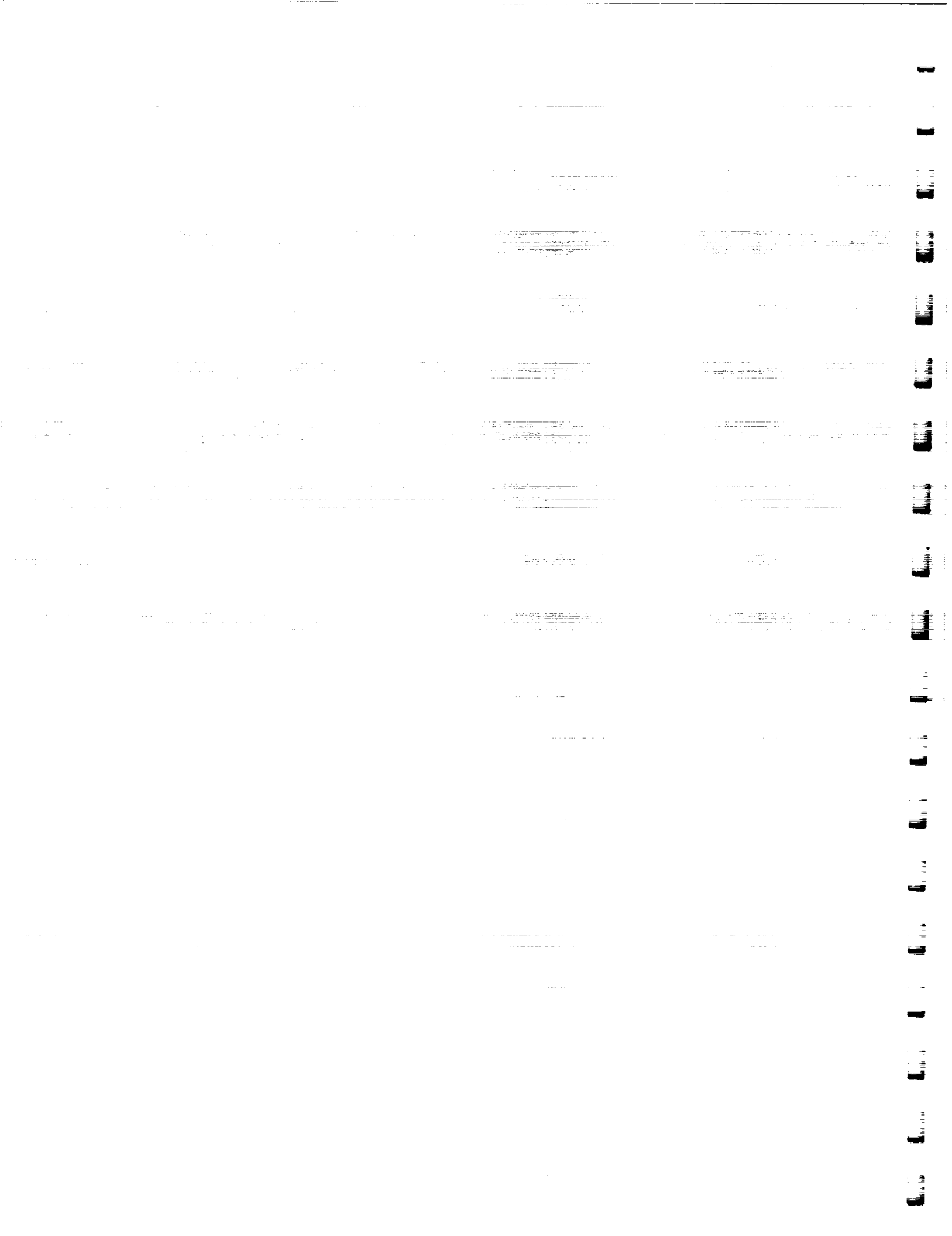
General Surgery: A 36 percent outside referral rate for surgery, the most common being hernia repair.

Orthopedic: A 27 percent referral rate. The most common procedure performed was arthroscopy, followed by fracture reduction.

SUCCESSFUL COMMERCIAL APPLICATIONS

Successful commercial applications of telemedicine will require an understanding of the factors discussed here today. Most important is the need to clearly demonstrate to the buyer that there is in fact a value added benefit to the use of communications technology for the delivery of quality health services to remote locations. The total value added must equal or exceed communications and technology costs.

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Space Technology in Remote Health Care

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INTRODUCTION

Crews and passengers on future long-duration Earth orbital and interplanetary missions must be provided quality health services—to combat illnesses and accidental injuries, and for routine preventive care. People on Earth-orbital missions can be returned relatively easily to Earth, but those on interplanetary missions cannot. Accordingly, crews on long-duration missions will likely include at least one specially trained person, perhaps a physician's assistant, hospital corpsman, nurse, or physician who will be responsible for providing onboard health services. Specifically, we must determine the most effective way to administer health care to a remotely located population.

Many similarities exist between administering quality health care in a spacecraft and administering the same care to a remote population on Earth. In remote areas on Earth, health care is often administered under less than optimal conditions (e.g., limited clinical equipment, lack of adequate surgical and therapeutic facilities, coupled with the limited ability to consult with specialists). An electrocardiogram (ECG) from a crewmember in a spacecraft can be communicated to the ground in a nearly identical way as from a patient in a remote location on Earth. A high-resolution television presentation of an X-ray picture of a fracture from a space traveller might be transmitted and evaluated the same way as an X-ray obtained and transmitted from a patient on Earth.

We must determine the probability of illnesses and injuries in space and provide procedures, equipment, instruments, and pharmaceuticals to diagnose and treat them there. We must define the medical and surgical skill required of the onboard health-care provider. We must also determine the extent of guidance that can be given in handling serious medical emergencies by two-way voice communication and vehicle-to-ground television links. For example, an onboard physician might be guided step-by-step through emergency surgery by a fully qualified surgeon via a TV-voice link when ground contact is possible.

Significantly, the communication and data processing systems required on long-duration space missions may also be similar to those required for providing remote health-care services on the ground. Thus, operating a "test bed" health care system in selected remote locations on Earth

can provide a reasonable simulation for gathering information that could be applied to designing a flight system. This approach has "spin-off" potential, in that space technology employed in the basic design of a flight system may eventually improve the quality of health care delivery on Earth.

Citizens of remote areas on Earth face an ever-increasing shortage of quality health care. This problem results from national shortages of trained physicians, remote areas being unable to attract new physicians, and geographic dispersal of populations and medical capabilities, among other reasons. A system that allows physicians to administer quality health care to patients in remote areas, without being physically present, may provide a satisfactory solution.

As a result of these considerations, the National Aeronautics and Space Administration (NASA), with the cooperation of the Department of Health, Education and Welfare (HEW), is pursuing a program for providing health services to a remote location on Earth as a necessary step to developing and verifying this capability on a spacecraft. The content of this demonstration program is described below.

THE STARPAHC PROGRAM

The overall goal of this program is to assemble a ground-based remote area health care delivery system and operate it for 2 years in a remote location. The specific objectives are:

- To provide data for developing health care for future space crews through:
 - Further development of the physician-paramedic link
 - Clinical evaluation of advanced bioinstrumentation
 - Development of computer support for "remote" health care
 - Integration of video viewing and display devices
 - Definition of skills, training and procedural requirements
 - Evaluation of existing techniques for space application
 - Identification of areas requiring technology advancements
 - Refinement of protocols and techniques
- To improve the delivery of health care to remote areas on Earth through:
 - Improved communication methods
 - Mobile health clinic
 - Advanced health care equipment
 - Computer aids
 - Assistance to allied health professionals and health education programs

On April 17, 1973, HEW Secretary Caspar Weinberger announced that the Papago Indian Reservation in Arizona would be the site for operational testing of a system to "improve medical care in space and remote Earth locations." Accordingly, the program now is identified with the

name STARPAHC, which is an acronym for Space Technology Applied to Rural Papago Advanced Health Care.

The Site: The Papago Indian Reservation, Arizona. The Papago site was selected by HEW and NASA for several reasons, including the community's willingness to support the cost of the system after the test period was completed, and its willingness to accept primary care from physician's assistants. Arizona is one of 28 states that allow physician's assistants to provide primary care. The beneficiaries of this program would be the 8-10 thousand permanent residents of 75 villages in the Papago reservation, and also the 2-4 thousand who live outside the reservation's boundaries but return there for health care. The tribe governs itself through a tribal council and has complete police jurisdiction on the reservation. The average family size is 4.8 persons, and the median age is 21 years.

The Papago reservation covers approximately 11,180 square kilometers (4,300 square miles) east of Tucson and south of Phoenix with the Mexican border on its southern boundary. The reservation is in the Sonora Desert—a rough, dry terrain with intermittent mountain clusters. Utilities, where available, are of fair to poor quality. Power outages of 6 hours or more are frequent in July and August, even in Sells and Santa Rosa, the "big cities." Water is supplied to villages by wells. Highways are asphalt-surfaced, but other roads are graveled, unpaved and bumpy, and can be hazardous immediately after rainstorms. The main industry is raising cattle; the average annual income is approximately \$900 per family.

The HEW's Indian Health Service (IHS) administers health care on the reservation through a hospital at Sells and a part-time clinic at Santa Rosa. A large, well-equipped Indian Health Hospital in Phoenix has many specialists on the staff. In the STARPAHC system, Sells and Santa Rosa were selected as key elements for the Support Control Center (SCC) and the Local Health Services Center (LHSC), respectively. Also, the Phoenix hospital is the primary referral center (PRC). A Mobile Health Unit (MHU) is used to deliver health-care services to remote villages. The MHU is a well-equipped mobile facility staffed by physician's assistants. These system elements are described in more detail below.

SYSTEM CONFIGURATION

The STARPAHC system synthesizes a series of basic facilities, service elements and supporting functions into an operating system. The system consists primarily of:

1. The Health Services Support Control Center (HSSCC or SCC) is located in a wing of the Sells Hospital and is analogous to NASA's Mission Control Center. It is staffed by physicians and a system operator.

2. A Local Health Service Center (LHSC) is the Santa Rosa Clinic. It is staffed by a physician's assistant and functions as a fixed remote clinic.
3. The Mobile Health Unit (MHU) is a clinically equipped van-type vehicle staffed with a physician's assistant and a laboratory technician. It functions as a remote mobile clinic, visiting villages on a preselected route and schedule.
4. The Phoenix Referral Center (PRC) is a dedicated room in the Indian Health Hospital in Phoenix for access to specialists, through audio and slow-scan television links with SCC, LHSC, and MHU.
5. The Tucson Computer Center (TCC) provides STARPAHC data system access to the IHS Health Information System data base.
6. The Quijotoa Relay Station (QRS) is used for microwave and VHF transmission of television, voice and data between major system elements.
7. The Telecare Unit (sometimes called PAM) is a suitcase-size, portable, ambulance-carried selection of medical equipment for emergencies and house calls to bedridden patients.

System Operation. The basic operational features of the STARPAHC system are:

- Medically trained Community Health Medics (CHMs), commonly known as "physician's assistants," are at the fixed (LHSC) and mobile (MHU) clinics. These CHMs administer health care to patients under the direct supervision of the physicians who are miles away at the Sells Hospital (HSSCC). The CHMs are linked to the physician through radio and TV hookups, allowing the physician to view the patient, the affected body area, X-rays, microscope slides, etc. Simultaneously, descriptions and responses to the physician's questions (by the CHM and patient) can take place via the radio link. This in effect extends the high-quality diagnostic and treatment capability of the physician over large distances and several clinics while he or she is at a hospital (the HSSCC).
- An automatic data processing network supports the activities of the physician, CHM, laboratory technician and other system personnel by enabling them to request important information from the computer using keyboarded terminals. The requested information is displayed on a TV-type screen almost instantaneously and can include patient histories, instruction for care, diagnostic aids, etc. After the patient's visit, information is entered into the data system via the same terminals so that all patient information is current.
- When the physician at the HSSCC wants to consult with a specialist in the Phoenix Indian Health Hospital through the HSSCC, views of X-rays, wounds, lesions, patients, etc., can be transmitted from either clinic to the specialist's station using

the slow-scan TV. A direct telephone line is also available for discussion with the specialist.

- This combination of capabilities enables patients at the remote clinics to be diagnosed by the physician miles away at the hospital, and to be treated immediately by the CHM in the clinic under the physician's direction. The entire activity is accomplished quickly, without the need for traveling considerable distances.

The Mobile Health Unit (MHU). The MHU is a mobile clinic that visits villages on a scheduled basis. Staffed by CHMs and laboratory technicians, the MHU gives the physician a flexible "outreach" capability. Its use and features are summarized below.

A patient enters the reception area and is interviewed by a CHM to determine complaint, symptoms, duration, etc. The CHM calls up a patient history or other pertinent information as needed using the data terminal keyboards. Patients are examined in the examining room, where the physician is in radio contact with the CHM and can view the patient via TV (CHM uses the color TV camera above the examining table). If the physician decides that a view of a body orifice (e.g., the throat) is necessary, then the CHM uses the patient-viewing microscope (PVM), under voice direction of the physician, while checking the TV monitor. The PVM uses fiber optics to illuminate the viewing area and to return the image to a TV camera, from which it is transmitted to the physician at the HSSCC. Should the physician wish to review slides, such as blood smear or culture, the trinocular microscope assembly includes a TV camera to transmit the view through the microscope. The laboratory area is equipped to conduct biochemical analyses usually required for clinical examinations (blood work, urinalysis, etc.). When X-rays are required, they are taken and developed in the X-ray room. This room also contains equipment enabling the technician to transmit the X-ray to the physician at the HSSCC via TV.

Santa Rosa Health Center (LHSC). The Local Health Services Center (LHSC) is an existing clinic, the capabilities of which are enhanced by the equipment and staff needed to meet its functions in the STARPAHC system. The LHSC is staffed with CHMs, laboratory technicians, and a secretary/receptionist. Like the MHU, its function provides the physician at the HSSCC with "outreach" capability to deliver quality health care to patients through STARPAHC. It has considerably more usable area for clinical examination, patient treatment and laboratory facilities than does the MHU. Its operational procedures for patient, CHM, or physician activity are generally the same as those described for the MHU.

Sells Hospital (HSSCC). The HSSCC is the base for the STARPAHC operations. The Indian Hospital at Sells, Arizona, contains a portion of one wing as the STARPAHC system HSSCC. Here the physician directs the CHMs, laboratory technicians, communicates with patients and calls up data to assist in patient examination and treatment. The physician can also consult with specialists at the Phoenix Indian Health Hospital (PRC) and direct functions of the

system operator, such as recording the TV image, sending slow-scan X-rays to the PRC, or "patching in" other needed capabilities.

As the operational base, supporting engineering functions such as scheduling, logistics, maintenance, reporting, etc., are managed and controlled from the HSSCC. The HSSCC also houses the system data processing equipment and maintenance functions.

Physician's Console (HSSCC). The physician's console in the HSSCC is the focal point of the system. As the system's control center, it provides physicians with the required displays and controls. These controls and displays have been selected carefully for maximum flexibility as well as maximum ease of use. Privacy on voice and TV circuits can also be controlled. Most important is the capability to control the TV cameras at the MHU and LHSC directly from the physicians console/for optimal visualization of the patient.

Phoenix Referral Center (PRC). The referral center at the Indian Health Hospital in Phoenix (the PRC) is staffed with and has access to medical specialists. In the STARPAHC system, these specialists can be called upon to consult with the HSSCC physicians when unique or complex medical advice is in order. To enhance the consultation, the system allows transmission of X-rays or pictures of the patient, lesions, etc., via slow-scan TV using existing telephone lines. These same telephone lines also allow voice communication and data transmission between the HSSCC and the PRC. The slow-scan capability provides X-rays or picture transmission in 45 to 90 seconds. It inherently records the transmission, which enables almost unlimited playback for extensive study at different times and for various durations.

PROGRAM PARTICIPANTS

- The Papago Indian Tribe and its Executive Health Council
- The HEW Health Resources Administration
- The Indian Health Service Center for Research and Development
- The NASA Office of Manned Space Flight
- The Lyndon B. Johnson Space Center, Life Sciences Directorate, Bioengineering Systems Division
- The Lockheed Missiles and Space Company, Inc. (contractor to NASA)

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1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes the need for transparency and accountability in financial reporting.

2. The second part of the document outlines the various methods used to collect and analyze data. It includes a detailed description of the sampling process and the statistical techniques employed to interpret the results.

3. The third part of the document presents the findings of the study. It shows that there is a significant correlation between the variables being studied, which supports the hypothesis that was tested.

4. The fourth part of the document discusses the implications of the findings for future research and practice. It suggests that the results could be used to inform policy decisions and to guide the development of new programs and initiatives.

5. The fifth part of the document provides a conclusion and a summary of the key points. It reiterates the importance of the study and the need for further research in this area.

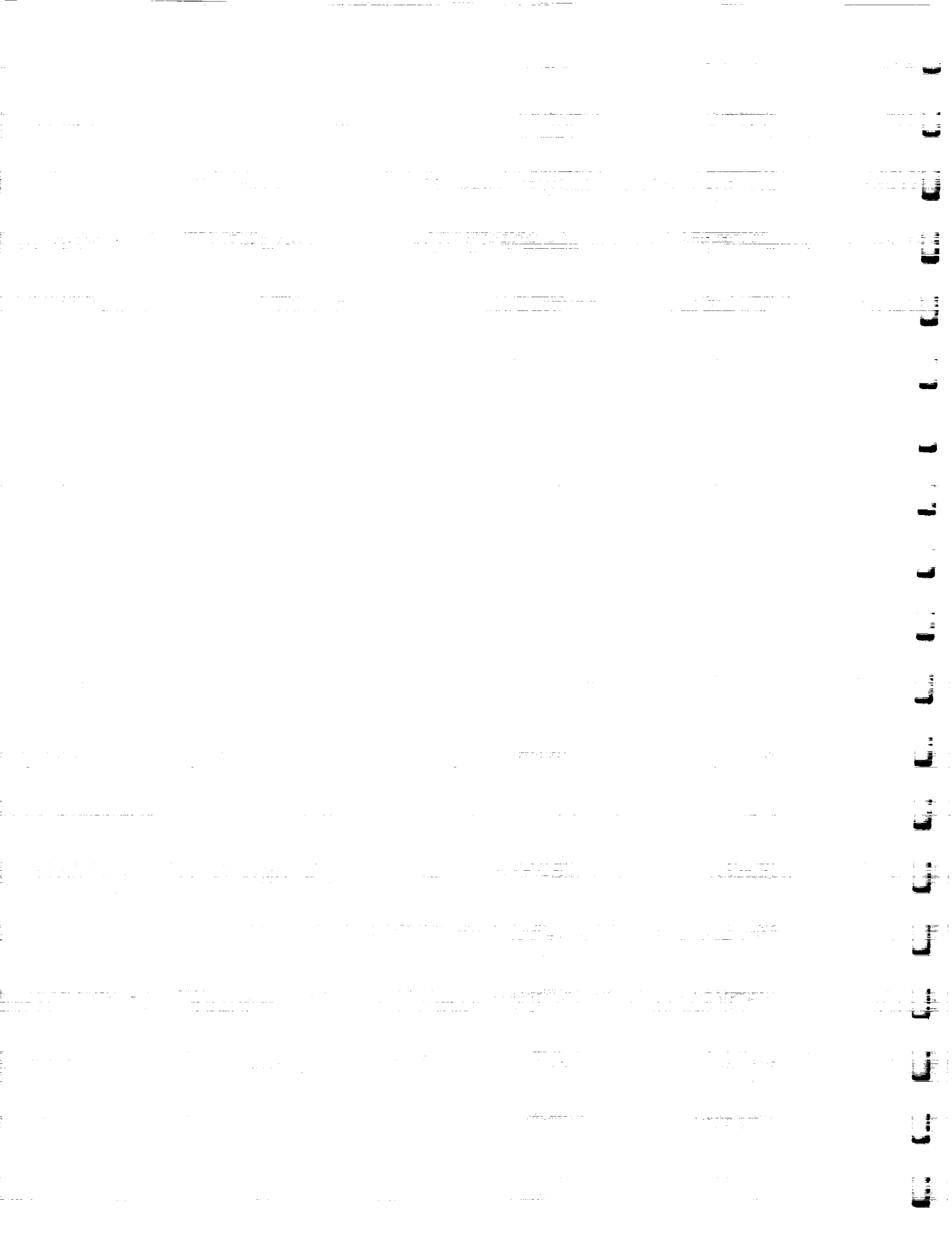
6. The sixth part of the document includes a list of references to the sources used in the study. It also includes a list of appendices that provide additional information and data.

7. The seventh part of the document is a glossary of terms used in the study. It defines the key concepts and provides a clear understanding of the terminology used throughout the document.

8. The eighth part of the document is a list of figures and tables. It includes a description of each figure and table and provides a clear understanding of the data presented.

9. The ninth part of the document is a list of footnotes. It includes additional information and references that are not included in the main text of the document.

10. The tenth part of the document is a list of page numbers. It provides a clear understanding of the structure of the document and the location of each section.



The Use of Communication Technology in Medicine

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NYNEX Science and Technology is engineering a multi-layered approach to multimedia communications by combining high-resolution images, video, voice and text into a new fiber-optic service. The service, Media Broadband Service (MBS), is a network-based visual communications capability. It permits real time sharing of images in support of collaborative work among geographically dispersed locations. The health care industry has been identified as a primary target market due to their need for high resolution images, the need to transport these images over great distances, and the need to achieve the transport in a short amount of time.

This paper will describe the NYNEX Corporation, the current state of the MBS project, including the market needs driving the development of MBS, the overall design of the service, its current implementation and development status, and the progress of MBS projects underway for various customers participating in the initial service offering.

NYNEX OVERVIEW

The NYNEX Corporation is a major U.S. provider of telecommunication services. Its mission is to be a world-class leader in helping people to communicate using information networks and services. Through New England Telephone, New York Telephone and NYNEX Mobile Communications Company, NYNEX provides wireline and wireless telecommunications services to approximately 12 million customers in the northeast United States. The corporation also offers these services in selected markets around the world through NYNEX Network Systems Company. The BIS Group is a worldwide information services organization that provides consultancy, information systems, banking systems and marketing services to finance, industry and government.

The NYNEX family of companies provides directory publishing, database management, information delivery, software and consulting services for customers in the United states and more than 60 other countries.

NYNEX Science & Technology, Inc. is the corporation's research and development facility. Its mission is to develop strategic technologies for new and emerging products and

services within the NYNEX family of companies. Our approach is primarily customer focused and driven. We respond to requests from customers to resolve specific communication problems by conducting in-depth research into their business and communication needs. MBS has been developing in response to customer needs in dealing with image-based and multimedia data.

MEDIA BROADBAND SERVICE

Media Broadband Service (MBS) is a network-based visual communications capability. It permits real time sharing of images in support of collaborative work among geographically dispersed locations.

MBS consists of network transport and intelligent software. The software (MEDOS) has been designed to correctly identify the needs of the application user and the capability of the transport and switch to establish multimedia conversational sessions.

THE NEED FOR MULTIMEDIA COMMUNICATION SYSTEMS

In response to the needs of our customers, NYNEX Science & Technology has undertaken the development of the MBS multimedia communications service and related applications. Customers have suggested that the ability to access, transport and interact with image-based information modalities is not fully and efficiently achieved via existing services. As a result, the decision to develop a new multimedia service was taken for primarily two reasons.

First, we see an obligation to continue to serve the communication needs of our customer base as their communication requirements evolve. We are ideally positioned, in terms of resources and expertise, to facilitate the migration of customers from conventional services to more advanced ones. Our extensive fiber-based resources allow us to quickly and conveniently implement high-bandwidth-dependent services across private and public networks.

Secondly, we see the future of telecommunications to be inextricably bound to the evolution of multimedia services. Future communication environments will be permeated with image-based and mixed-media data; evolving and future networks must not only be capable of transporting increased volume of data, they must be able to manage and coordinate interaction between users manipulating that data. NYNEX recognizes the need to address this challenge in order to preserve its ability to provide world-class communication services.

THE NYNEX APPROACH—CUSTOMER FOCUS

The NYNEX strategy for developing MBS from a research endeavor into a viable product focuses primarily on working closely with, and exchanging feedback and experience with, strategic customers. In this manner, we are positioned to develop a service that is both technically and functionally responsive to the customer's needs. This strategy is pursued in a number of ways:

- Strategic relationships are formed with key customers whose needs cannot be met by existing approaches.
- Research and analysis is conducted to fully understand each customer's business and communication environment.
- A prototype system is developed in the laboratory. The prototype environment is constructed to model the customer's working conditions.
- A prototype system is deployed at the customer's site, yielding valuable feedback and experience.
- The product/service is refined to provide better service for key industries.
- The service is marketed to those industries.

CUSTOMER REQUIREMENTS

Customer requirements for image-based multimedia communications usually arise out of the deficiencies apparent in conventional communication environments and presentation modalities. Customers want to replace existing telecommunication and telecomputing environments with one that will support:

- **Image-based Conversations:** The primary element of communication should be the image rather than text or voice. Transport capacity must be sufficient to allow the conversational manipulation of images between users.
- **Collaborative Work:** Connectivity and response time must be sufficient to allow multiple users to interact as if they were face to face.
- **Natural User Interfaces:** The man-machine interface must be intuitive, flexible, and simple. (A multimedia environment makes this goal more easily attainable than conventional environments.) Esoteric command-based interfaces must be avoided.
- **Dispersed Geographical Sites:** The communication environment must be capable of spanning Local Area Networks (LANs) and Metropolitan Area Networks (MANs).

- **Separations in Time:** The environment must be capable of supporting disjointed dialogues between users who may never be simultaneously available. A multimedia store-and-forward system must be supported.
- **Fast Response Time:** Communication functionality must be backed up with sufficient transport and performance capability to allow near-real-time response.

THE MBS SOLUTION

While there is much discussion and research being conducted in regard to multimedia technology, there is still much confusion regarding the basic definition and tools of this technology. We differentiate multimedia communications from multimedia presentations. Whereas multimedia presentations are concerned with the rendering of mixed-media elements to one or more spectators, multimedia communications involve the interactive and collaborative manipulation of mixed media elements under the control of independent users. Multimedia presentations consist of the mere playback of mixed-media elements according to some script (either fixed or variable, i.e., under the control of the spectator). Multimedia communications, however, allow users and applications to interact with one another within an environment that supports mixed-media elements. In this sense, multimedia presentations are only one element within a multimedia communications environment.

A multimedia communications environment must support the following key elements:

- **Multiple Users:** Users must be able to interact and collaborate with one another in a dynamic and conversational mode. It must be possible to add and remove users from ongoing multi-user sessions.
- **Multiple Process/Processors:** Users must be able to interact with several different single- or mixed-media processes at the same time. This means that each user can participate in multiple sessions concurrently, and within each session, multiple processes can be active.
- **Conversational Computing Environment:** Interaction between users must be as natural as possible; dialogue must take place as if users were gathered around a conference table.
- **Utilization of Voice/Data/Text/Images/Video:** All mixed-media data types must be supported. It must be possible to recognize, combine and separate these types within the multimedia communications environment.
- **Fully Integrated Network Environment:** All users and resources on the multimedia communications network must be continuously and seamlessly accessible.

- **Transparent Interface:** All customers must be able to access the network without the requirement to manually set up, maintain, or terminate interaction with the network. All applications must be able to access network resources and users without regard to the user's or resource's particular network interface.
- **Allow Near-Instantaneous Response:** Transport and processing capacity must be sufficient to allow users to maintain a near-real time conversational mode. Network-wide resources must be immediately and continuously available.

MBS ARCHITECTURE

The MBS architecture combines an intelligent network with broadband transport.

MBS is a distributed software environment consisting of high speed optical transport, intelligent networking software, adjunct data servers and specialized imaging applications. It is based on an open network architecture employing several distributed client server relationships orchestrated by a network server. The network server is the controlling agent and can operate both at the LAN level and at the MAN switching hub.

In order to meet the demands of end users, MBS is designed to achieve its goals by providing the following key features:

- **Broadband Transport:** By making use of the existing and newly installed New England Telephone fiber networks, MBS can deliver inter-site service at a rate of 1.5 megabits to 45 megabits per second or greater.
- **Sessioning Environment:** The network software provides a session-based communication environment in which users can share, display and manipulate data. Uses of such an environment range from a common window and pointer (allowing users at separate workstations to enter into a multimedia conference to simultaneously view, point at and modify objects within a common window) to a transport environment within which data can be transmitted between end points without any special user setup or control of transport links.
- **Resource Servers:** The network supports resource servers that provide commonly used general services. The file server provides an efficient, centralized multimedia database available to users for data storage and retrieval at network speeds. The mail server provides a multimedia mail service capable of forwarding, storing, delivering and tracking multimedia messages in multimedia envelopes. The directory service provides a text-based or multimedia-based catalogue of all users, resources, servers. Media Broadband Service (MBS) is a network-based visual communications capability. It permits real time sharing of images in support of

collaborative work among geographically dispersed locations. MBS consists of network transport and intelligent software. The software (MEDOS) has been designed to correctly identify the needs of the application user and the capability of the transport and switch to establish multimedia conversational sessions and facilities available throughout the network.

- **Open Interface:** By providing an open and flexible interface to the network's sessioning capability, existing applications can be modified and new programs designed to run in a multi-user, multi-session environment.
- **Public Access:** By making MBS available as a public switched network, any subscriber can make use of the service from any network-accessible location, allowing maximum flexibility for businesses to decentralize their operations and also allowing consumers to access the service on an as-needed basis.
- **Flexible Configurations:** MBS supports centralized, localized, and distributed configurations. The network processor(s) can be located in one or more private LANs, one or more public network central offices, or a combination of both.

MARKET OPPORTUNITIES

MBS addresses and fulfills a number of existing market requirements that would otherwise be addressed through disjointed or modular approaches. A common requirement across all industries is the need to increase revenue while containing expenses. This is achieved in a different fashion in each industry.

Healthcare. This industry relies heavily on very high quality images. Currently there is a strong reliance on hardcopy images and LANs. MBS offers the opportunity to move away from hardcopy images to electronic representations, easing the current burden of archival and transport of physical images. Perhaps even more significant, MBS allows specialists to be physically separated from each other (specialists can confer between workstations with full visual/audio communication, and specialists from remote hospitals can pool resources), as well as the point of data generation (allowing remote viewing of medical imaging studies from home or office rather than the location at which the study originates).

In the healthcare industry, the goal of generating new revenue can be achieved via MBS by making existing and new services available to remote locations, meaning that strategic equipment and expertise do not have to be in the same location to be used effectively. Expenses can be controlled and minimized by maximizing professional productivity through consistent and immediate access to images and information that would otherwise be inconvenient to obtain.

Similarly, hardcopy duplication, equipment redundancy, and reduction in the volume of hardcopy-production consumables could be achieved.

Publishing. This industry relies on high-quality images in a time-critical production environment. Page and document review/modification can take place over great distance without producing or transporting hardcopy representations. Pre-press production cycles can be shortened or more pages can be produced in less time. Archived elements can be retrieved or stored more efficiently and in a more timely manner.

Advertising. This industry relies on high-quality images throughout the review and production process. Interdepartmental and client-agency exchange and review of ad proofs can be greatly streamlined. Changes to images can be generated and presented within a multi-user interactive session, greatly reducing the necessity, as well as the time and expense, of moving physical images or personnel between locations.

In the advertising/publishing industries, increased revenue can be generated by reducing time to market via the increased efficiency in production and review cycles afforded by MBS. Expenses can be contained by making individuals more productive (through increased access) and resources more widely available. Real-time electronic proofing of images within a multi-user session will greatly reduce the expense associated with hardcopy proofing and the delay in transport between geographically diverse locations.

WHO IS THE CUSTOMER?

Other image intensive industries that could benefit from MBS are:

- Education and Training
- Manufacturing and Retailing
- Real Estate and Tourism
- Architecture and Construction
- Design and Engineering
- Banking and Securities.

BOSTON TRIALS

NYNEX has a mutual commitment with four major hospitals and a major publisher in Boston to conduct trial implementations of the Media Broadband Service. The trial participants are:

- The Children's Hospital
- Massachusetts General Hospital

- New England Medical Center.
- Brigham & Women's Hospital

The goals of the trials are:

- To gain experience in how the system functions under real-life conditions;
- To acquire feedback from customers on the performance and design of the service;
- To solve particular communication problems for each of the trial participants;
- To provide high quality service in an environment that matches actual public networking conditions.

THE CHILDREN'S HOSPITAL

The Children's Hospital is well along in their effort to create an automated electronic medical record system; however, that system is text-based and does not allow for image-based or multimedia communication. MBS provides a multimedia communication environment that allows TCH to make use of the following image-intensive applications:

- **Report:** This application will be used to assemble multimedia medical reports comprised of images, voice annotation and text. Users will be able to access, manipulate and enhance the associated images from remote and local facilities.
- **Review:** This application will allow users to make use of existing multimedia reports either to acquire up-to-the-minute patient information, or to use in the construction of new reports. Users will be able to review the reports and associated images from remote and local facilities.
- **Consult:** This application will allow multiple specialists in separate locations to confer while simultaneously viewing diagnostic images and associated test and voice annotation.

MASSACHUSETTS GENERAL HOSPITAL

MGH is a large organization spread out over a relatively large geographical region. Access to information, images and personnel is hindered by the inability to conduct real-time collaboration between sites. The difficulties in transporting hardcopy medical imaging studies between facilities results in significant loss of opportunity in providing patient care and maximizing revenues.

MBS will provide the capability to conduct multi-user multimedia sessioning between sites in collaboration with the existing PACs (picture archiving system). As a result, MGH will be able to transport, access and share multimedia information across the following locations:

- Somerville Film Library
- Charlestown MRI Site
- Spaulding Hospital
- Harvard Community Health Plan
- Massachusetts General Hospital.

BRIGHAM & WOMEN'S HOSPITAL

Brigham & Women's Hospital (B&W) will use MBS primarily for teleradiology applications. With various SUN workstations located throughout the institution on an ethernet LAN, radiologists, physicians, and surgeons will be able to simultaneously review magnetic resonance imaging (MRI) and computed tomography (CT) images. Additional workstations will be located in the homes of specialists who will be able to review images and consult with on-site personnel on an on-demand basis, greatly reducing the time involved in responding to emergency situations. The ability to conduct teleradiology through the MBS network will not only benefit clinical diagnosis and treatment, it will also enhance the research capabilities of the institution by facilitating the increased flow of information between departments.

NEW ENGLAND MEDICAL CENTER

New England Medical Center (NEMC) will integrate MBS network service into its existing FDDI LAN. DEC workstations will be used for a telecardiology application allowing for both remote private viewing and multi-user collaborative viewing of full-motion video images of catheterization of a patient's heart or blood vessels. When conducted within a multi-user session, this application will allow physicians at remote locations to simultaneously view a video loop while having access to a common pointer, useful in isolating or describing a particular part of the video.

This application will allow technicians to present studies to specialists moments after they are generated, allowing those specialists to determine diagnosis and treatment immediately. In emergency conditions, the time saved by such an application can mean the difference between life and death; in non-emergency cases, such an application can significantly reduce costs and time. For example, if a specialist has access to a study while a patient is still "on the table," the specialist can order additional studies to be conducted upon the patient immediately, rather than on a subsequent visit.

TRANSPORT REQUIREMENTS

The trial implementation configuration consists of a combination of local and centralized MBS network processors linked via T1 and T3 transport links. At the hub of the network is the Cambridge Applications Services Center, in which a centralized MBS processor and simulated central office (CO) are located. Linking each of the trial participants' sites to the CO are T1 (1.5 Mbps) and T3 (45 Mbps) capacity transport links.

The connections allow for inter-site communication, access to centralized network services, and in the case of MGH, they also allow for intra-organization inter-site communication. Local to each of the sites is a dedicated MBS processor that is responsible for all intra-site multimedia communications, either over ethernet or FDDI, depending on the facilities available.

TRIAL RESULTS

The trial implementation will yield valuable information for future refinements and enhancements to the service. Specific areas of interest include:

- **Usage Patterns:** Indicate how to provision and configure processing and transport resources.
- **User Preferences:** Indicate how to refine existing functionality.
- **Design Discrepancies and Omissions:** Indicate how to enhance the service.
- **Basic Functionality Requirements:** Indicate common features for all target industries.
- **Ease of Application Integration:** Indicate how to facilitate and encourage application development.
- **Actual Revenue/Expense Benefits:** Indicate cost-effectiveness of the service.

FUTURE DIRECTIONS

We have outlined our strategy in developing and implementing MBS. Our basic approach has been to respond to the specific requests of our customers in conjunction with general market requirements in order to provide a communications network capable of supporting a multimedia environment. This environment has been specifically designed to integrate with existing and emerging technologies so that required modifications to technologies already in place will be kept to a minimum.

Significant progress has already been achieved in the healthcare and publishing industries. As existing industry-specific applications are refined and new ones developed, the benefits of

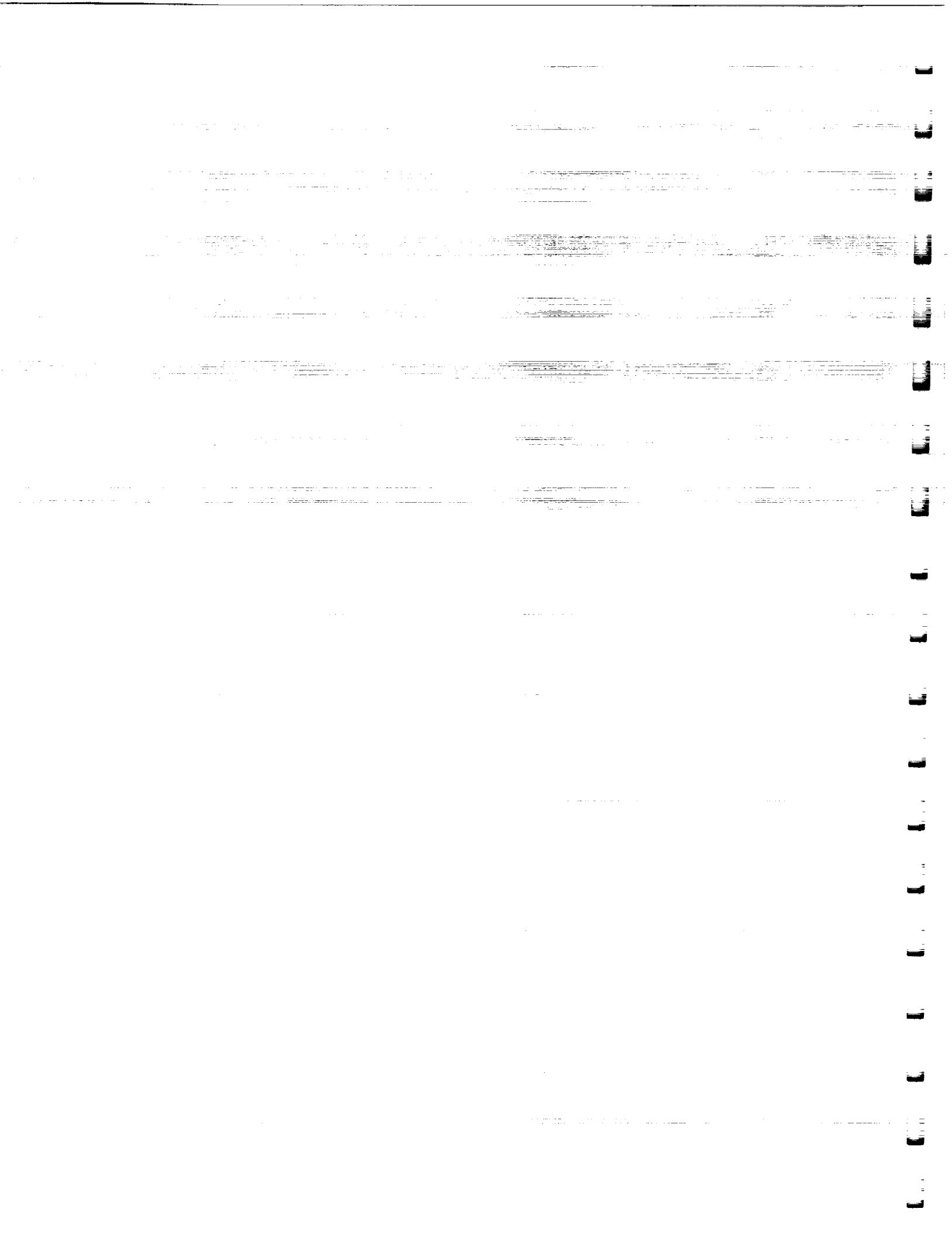
multimedia communication will emerge and stimulate further development of enhanced network services and general-purpose applications.

To continue upon this course, several additional steps must be taken. the service must be field tested in other industries and with more complex configurations. New applications must be developed to take full advantage of current and future network services. Established applications must be ported to MBS to allow users transparent access to network capabilities.

Development of a market for multimedia application will rely on software being produced to provide multimedia communications, continual advances in multimedia terminal development, willingness of the hospitals to encourage cooperation between their clinical systems and their fiscal systems in the areas of billing and transaction processing, and industry cooperation in the development of standards and open network interfaces.

As these challenges are met, multimedia communications will become an essential tool for business and industry. This communication environment will offer new ways of maximizing expertise and resources, allowing increased efficiency and productivity in image-based and mixed-media applications.

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The National Disaster Medical System

Thomas P. Reutershan
Director, Office of Emergency Preparedness
National Disaster Medical System
U.S. Public Health Service

INTRODUCTION / BACKGROUND

Overall our nation is well equipped to provide traditional emergency medical services or "EMS" and the majority of EMS responses in our country are single victim incidents involving serious illness such as heart attacks, or injury resulting from automobile accidents, et cetera. Most of our major metropolitan areas are well prepared to deal with multiple casualties resulting from train wrecks or bus crashes and the like.

The problem is—What do we do when a big one hits? And we've been very fortunate in the United States. We haven't had a big one in over 80 years—not since 1906, the great San Francisco earthquake, have we had a catastrophic disaster with a mass number of casualties.

However, we've been reminded recently, with the earthquake in Soviet Armenia, that such catastrophes do occur. Someday, one will occur here. Not just likely to occur, but it's going to occur, somewhere in the United States.

It's also been a couple of decades since we've been involved in a conventional armed conflict which produced mass numbers of casualties among members of the U.S. Armed Forces. And although the number of military medical facilities in the United States may look very impressive, the bottom line is that all of the facilities add up to only 16,000 beds. Compare that to over a half a million military hospital beds that existed during World War II. Casualty projections for an overseas conventional conflict today with current sophisticated weaponry will far exceed the capacity of the Department of Defense to provide needed care. And even with the primary backup support of the Department of Veterans Affairs (approximately 32,000 additional beds could be provided by the VA), that capacity would also soon be exceeded if we were to engage in an overseas conventional conflict.

There were two issues that needed to be addressed. The major catastrophic domestic disaster, and the possibility of an overseas conventional conflict. In 1981 the President was concerned about both of these issues, concerned enough that he directed a series of initiatives designed to improve national policies and programs to address preparedness. He established the Emergency Mobilization Preparedness Board, chaired by his National Security Advisor, which

was composed of 23 Executive Branch departments. Members of the Board were either deputy or undersecretary level appointees. He also established a series of working groups including a principal working group on health, chaired by the Assistant Secretary for Health in the Department of Health and Human Services. He directed the Board and working groups to develop policies and programs to improve national preparedness for major domestic disasters and national security emergencies. He also directed the Board and working groups to make maximum use of existing resources.

The first product of the Board and working groups was National Security Decision Directive 47 (NSDD-47), which was approved by the President in July, 1982. This document not only set forth general policy, it also provided specific principles for carrying the policy forward.

Following the issuance of NSDD-47, the Board and working groups developed plans for improved national preparedness. Within the health and medical arena, the working group on health developed the concept and system design for the National Disaster Medical System (NDMS). Key steps in the establishment of the NDMS were included in a National Plan of Action on Emergency Mobilization Preparedness, which the President approved in March, 1983. NDMS was created for mastering the challenge to provide care in major catastrophic disasters here at home or for military casualties of a major overseas conventional conflict.

Although the impetus for developing the NDMS resulted from national level concerns, organization and successful operation of the system begins at the local ("grass roots") level. Local institutions, organizations and individuals have come together as part of the NDMS to improve their hometown disaster medical readiness. At the same time, these local NDMS assets are essential components for effective statewide and nationwide medical mutual aid.

NDMS—PURPOSES/KEY COMPONENTS

Thus, the purpose of the NDMS is twofold: to provide supplemental medical assistance to state and local officials in massive domestic disasters, and support the military and VA medical systems in caring for military casualties of a conventional conflict. At the Federal level, NDMS is a partnership and joint venture involving four major departments and agencies: the Department of Defense, the Federal Emergency Management Agency, the Department of Health and Human Services, and the Department of Veterans' Affairs. NDMS has three major components. First, medical response, second, a system of patient evacuation, and third, definitive medical care.

MEDICAL RESPONSE

Medical response consists of Disaster Medical Assistance Teams, or DMATs, plus the medical supplies and equipment necessary for the DMATs to perform their function. The DMAT is a volunteer group composed of about 30 physicians, nurses, technicians and other allied personnel, coming together and training as a volunteer unit. DMATs are, in the first instance, a community resource for supporting local emergency responders units in mass casualty incidents. Second, DMATs are also assets which may be used for medical response within their home state. Third, DMATs are a national resource that can be called on to provide interstate aid. Those DMATs that are capable of deployment to a distant disaster site will arrive in the area with enough supplies and equipment to be self-sufficient for a limited period of time, at least 72 hours. Much of the work at the disaster site will be to provide "triage," which is a French word meaning to sort patients according to their priority needs for care consistent with the medical resources available. In addition, DMATs will provide austere medical care, and those services necessary to casualty clearing and staging. "Clearing" and "staging" are terms borrowed from the military. "Clearing" refers to austere field medical care, and "staging" refers to those medical services required during patient evacuation. DMATs in local NDMS reception areas will provide medical services associated with receiving patients, assessing patients' medical needs and matching those needs with available local hospital capability.

Although the DMATs initially will be organized as non-Federal volunteers, and will train as non-Federal volunteers, upon activation of the system for a national emergency, DMAT members will become temporary employees of the Federal government—the U.S. Public Health Service. There are three reasons for doing this.

When DMAT members are appointed as Federal employees, potential problems of licensure and certification are avoided, particularly where teams are moved across state lines. In our country each state has unique requirements for licensure and certification of medical personnel. An individual may find it difficult to cross state borders and practice his or her profession without having a license in the state to which they travel. But as a Federal employee, a DMAT member can be sent to any state in the Union without regard to licensure and certification requirements.

The second reason for Federalization is liability. Individual medical personnel who go across state lines may be subject to personal liability in the event of an allegation of malpractice committed in the course of performance of their work. As Federal employees, however, DMAT members will have the protections of the Federal Tort Claims Act in which the Federal government becomes the defendant in a claim involving alleged malpractice.

The third reason for Federalizing DMATs is so the members can be compensated for their service. DMAT members who are taken from their normal place of employment, and moved into a

distant disaster site for 4 or 5 days, perhaps a week, should not suffer any personal financial hardship.

Each team will have a sponsoring organization, which could be a major medical center, public health agency or a voluntary organization, such as a local Red Cross chapter. The DMAT sponsor will organize and recruit the team, pre-enroll members in the NDMS personnel system to facilitate temporary appointment to Federal status, arrange for training of the team, and coordinate the dispatch of the team. Again, the DMATs are not reserved only for Federal needs. They are equally available to local and state authorities for use in responding to incidents that don't require Federal intervention or assistance. So the DMATs really represent assets, not just at the Federal level, but also at state and local levels.

Currently, about 50 of the 107 NDMS areas are in various stages of DMAT development. Our goal is to have at least one team in each area, and multiple teams in larger population centers. In addition to the general purpose DMATs, some specialized DMATs are being developed to respond to incidents involving mass burn casualties, hazardous materials exposures, etc.

PATIENT EVACUATION

The second key element of the NDMS is patient evacuation. The goal is to use systems that are simple and rapid, to recognize that there will be limited patient information, and also seek to use all types of transportation, but emphasizing air transportation because of the obvious time saving benefits.

The Department of Defense, and particularly the United States Air Force, has unique aeromedical evacuation capabilities, such as the C-9A Nightingale, a modified commercial DC9 passenger jet which can carry 40 litters. It also carries a medical crew of two flight nurses and three medical technicians. This aircraft is used today to transport military patients among various points within the United States and the Air Force operates 11 of these aircraft in the U.S. today.

Various cargo aircraft can also be utilized in aeromedical evacuation. The C-141 is used to transport military casualties from overseas sites to locations back in the continental United States. It can be configured to carry a combination of 48 litter and 70 ambulatory patients, or, with additional litter stanchions, it can carry 103 litter patients alone.

The C-130 is another cargo aircraft that can be used in aeromedical evacuation and can carry approximately 50 to 70 litters. This aircraft has a unique capability in that it does not require an improved runway for takeoff or landing. So if a disaster destroys or seriously damages the airports in the area, this plane could be used to bring in the DMATs and medical supplies and equipment and could land on a short stretch of interstate highway, in a desert, or field, and could also be utilized to evacuate patients.

The Department of Defense, the Department of Transportation, and several U.S. airlines are currently working on a new aeromedical evacuation program as part of the "CRAF"—CRAF standing for "Civil Reserve Air Fleet." This is a program that utilizes commercial aircraft and modifies them so that in a time of major emergency they can be utilized for purposes other than carrying passengers.

The Boeing 767 will be a part of an aeromedical segment of the civil reserve air fleet. The 767 will be configured to carry 111 litters. Twenty-five B-767s will become part of this program. The CRAF aeromedical segment will significantly increase the aeromedical evacuation capability of our nation.

DEFINITIVE MEDICAL CARE

The third key component of the NDMS is definitive medical care. In selecting potential patient reception areas three basic criteria were used. First we focused on areas that had a minimum of 2,500 operating, staffed acute care hospital beds. Second, areas were needed that had an airport which could accept aeromedical evacuation aircraft. Third, areas were selected where there was a facility which could serve as an NDMS local coordinating center. In all but one instance, the NDMS local coordinating centers are either military medical facilities or Department of Veterans Affairs Medical Centers. We do have one civilian coordinating center.

Each NDMS coordinating center has the following major responsibilities: coordinating overall NDMS activities in an assigned geographic area(s); soliciting and organizing community support for the NDMS, including participation by non-Federal hospitals, local emergency medical services (EMS) authorities, government officials and organizations, etc.; coordinating preparation of a local NDMS exercises in the assigned area.

The role of the participating NDMS hospital is to voluntarily pre-commit a percentage of its acute care beds by means of a memorandum of understanding. This not a legally binding contract. The hospital provides a minimum and maximum number of beds that could be made available on activation of the system. In an actual activation, the hospital could either increase or decrease the number of beds to be made available. Obviously, if the hospital admits patients through NDMS, it obligates itself to care for those patients using the generally accepted standards of medical care prevalent in that community. The hospital also commits itself to participate in periodic exercises which will help satisfy the requirements of the Joint Commission on Accreditation of Healthcare Organizations (JCAHO).

In return, the Federal government agrees to reimburse the hospital, attending physicians, and ancillary services, such as laboratory, anesthesia, blood bank, radiology, etc., on the basis of bills charged. But no money is provided up front.

There are over 1700 non-Federal hospitals currently enrolled in the NDMS. Additional hospital participation is being continuously explored.

Upon arrival, patients will be met by a local DMAT. They will be triaged, and assigned for priority transportation to local NDMS hospitals. Assessment of the patient's individual needs will be made by the DMAT against the available hospital beds in that area. A burn patient will go to a hospital that is best equipped to deal with that type of injury. An orthopedic patient will go to a hospital that has an orthopedic bed, etc.

Patients will be transported to the participating hospitals using local ground transportation, and where available, some patients may be transported by local helicopters. Upon arrival at the hospital patients will be provided with whatever definitive medical care is necessary to repair the injury or cure the illness.

NDMS ACTIVATION/OPERATIONS

How does NDMS get activated? Basically three ways. First, a Presidential declaration of a disaster under the provision PL 100-707, the Disaster Relief and Emergency Assistance Amendments of 1988. Second, a request for major medical assistance from a state health official under provisions of the Public Health Service Act. Third, in an overseas conventional conflict involving the U.S. Armed Forces, where casualty levels are likely to exceed or in fact do exceed the capacity of the DOD-VA medical systems.

In a domestic disaster, if state officials determine that there is a need for outside medical assistance, they may either contact the FEMA or PHS regional office or may directly contact the FEMA National Emergency Coordination Center (NECC) in Washington, D.C. The NECC is staffed and operated on a 24-hour basis. Personnel at the NECC, after receiving a request, would then contact an NDMS duty officer. The duty officer will verify the request and obtain additional information on what is needed where, etc., then the duty officer will obtain a decision to activate from the Assistant Secretary for Health in the Department of Health and Human Services. Upon receiving that decision, the duty officer will notify those organizations that will be necessary to initiate NDMS response and will also activate the NDMS Operations Support Center in Rockville, Maryland. The duty officer will also notify the official who requested assistance of the decision to activate the NDMS.

When NDMS is activated, there are a large number of organizations which would come together and work together.

Various Public Health Service (PHS) components would be activated. At the top is the PHS Office of the Assistant Secretary for Health (OASH), Office of Emergency Preparedness (OEP) (PHS/OASH/OEP).

Key Department of Defense (DOD) components would also be alerted and/or activated. At the top, DOD/DOMS is the Directorate of Military Support, Department of the Army. The Army serves as the DOD executive agent for providing military support to civil authorities.

Several other Federal and non-Federal organizations would also be alerted/activated as part of an NDMS response.

It is important to stress that each of the activated organizations retains full control of its own resources, so there's not going to be anybody saying, "you will do this and you will do that." The purpose of the NDMS Operations Support Center is not to direct or control, but rather to coordinate and process requests for assistance, to assure that those requests are channeled to the appropriate organization and let that organization do what it does best.

In a major catastrophic domestic disaster, normally under the auspices of FEMA, a disaster field office is established in or near the disaster site. As part of that field office an NDMS liaison would be assigned. The NDMS liaison could be a PHS regional health administrator or it could be an individual who is deployed from PHS headquarters. At any rate, as liaison, he/she would be responsible for channeling medical requests from the disaster area to headquarters so that appropriate response could be made, and so that patient evacuation could be provided from the disaster areas to NDMS reception areas.

Aeromedical evacuation liaison teams which belong to the Air Force would determine the requirement for airlift to evacuate patients. The liaison team would communicate that requirement back through the airlift control center, and the aeromedical evacuation control center, and the Military Airlift Command (MAC) would deploy the necessary aircraft.

A control team, another Air Force unit, would be deployed to the airport used as an evacuation point. The control team would control and communicate with the aircraft and participate in the dispatch of the aircraft to NDMS reception areas. The Armed Services Medical Regulating Office would match the evacuation requirements with bed availability based on bed availability reports it had received from local NDMS coordinating centers and regulate the flow of patients from the disaster area to NDMS reception areas. The NDMS Operations Support Center would be in communication with ASMRO and MAC and with the Disaster Field Office in providing assistance to the disaster area and participating in the overall operation.

In a military contingency, the activation of NDMS would work this way. Information on casualty levels would come from the theater of operations, to DOD, specifically to the Office of the Assistant Secretary of Defense for Health Affairs. Those data would be verified by that office and a decision to activate NDMS would be made and communicated to the NECC. An NDMS duty officer would again turn on the elements of the system needed to receive casualties in the designated NDMS reception areas.

It is anticipated that the Boeing 767 aircraft would be used for strategic evacuation from the theater of military operations to various predesignated cities in the continental United States ("hubs"). Some casualties would be hospitalized in NDMS facilities in the hub cities. Other casualties would be redistributed to their final destinations—other NDMS areas within the U.S. A Joint Medical Regulating Office (JMRO) would be established in the theater of operations, to accumulate casualty data for transmission to ASMRO. The JMRO coordinates with ASMRO for casualty regulation within the overseas theater and for return to the continental U.S. The NDMS Operations Support Center would participate in the overall operation.

SUMMARY/BENEFITS

In summary, NDMS is a combination of Federal and non-Federal medical resources coordinated in a single response system to meet civilian needs and also handle an overflow of combat casualties from a conventional conflict.

The key message is that the system can't work and won't work without the participation of local, state, and Federal levels of government, and the voluntary cooperation and participation of public and private sector organizations, institutions and individuals.

As of today, 75 coordinating centers, and 107 geographic areas are participating in the system. Over 1700 participating non-Federal hospitals, and over 110,000 non-Federal hospital beds have been precommitted as part of NDMS. As previously mentioned, about 50 areas are currently establishing DMATs.

What are the benefits of participation in NDMS? NDMS maximizes the use of existing resources. It has created nothing new but taken what's already available and organized it in a new way to cope with incidents that no single entity could ever deal with by itself. The system provides identifiable levels of care and seeks to match the patient with the appropriate level and type of medical care. It integrates the pre-hospital phase with medical facilities. It helps to contain health care costs by avoiding the construction of expensive facilities that are simply standing idle waiting for the "big one" to occur. The facilities and people utilized by NDMS are local resources that are working today to provide care. And, of course, the bottom line is the saving of life and limb—thus reducing mortality and morbidity.

A number of major national professional organizations have endorsed the NDMS, and several additional organizations have endorsements under consideration.

I think the advantages to our nation are obvious. In addition, there are benefits at the state and local level. The better prepared local areas are to support a national need, the better prepared they are to support local, state, or regional needs. With your support and participation, together we can master the challenge, and NDMS will be ready when needed.

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Satellite, Environmental and Medical Information Applied to Epidemiological Monitoring^a

Improved communications and space-science technologies, such as remote sensing, offer hope of new, more holistic approaches to combatting many arthropod-borne disease problems. The promise offered by these technologies has surfaced at a time when global and national efforts at disease control are in decline. Indeed, these programs seem to be losing ground against the arthropod-borne diseases just as rapidly as we seem to be moving forward in technological development. Given these circumstances, we can only hope that remote sensing and geographic information system (GIS) technologies can be pressed into service to help target the temporal and spatial application of control measures and to help in developing new control strategies.

Arthropod-borne diseases include those which encompass a vertebrate host, an invertebrate vector, and the causative agent of disease. The vertebrate host may be a human or some other animal. The vector is responsible for transmitting the agent of disease from one host to another.

In the case of human malaria, the vertebrate host is the human, the invertebrate vector can be one of about 40 species of anopheline mosquitoes, and the causative agent of disease is one of 4 species of intracellular plasmodial parasites.

Many arthropod-borne diseases are strongly associated with certain environmental conditions. Environmental conditions include climate parameters, e.g., air temperature, humidity, and rainfall; and landscape parameters, e.g., topography, vegetation, and soil. The principal environmental parameters, such as temperature and rainfall, regulate the geographical distribution of these diseases. Environmental conditions also regulate the seasonal occurrence of disease.

Recognition of the interactions between man, disease vectors and the environment date back far into the history of infectious disease research. The disease-environment relationships were formalized in Pavlovsky's research in the U.S.S.R. and his writings on landscape epidemiology¹. Pavlovsky noted that arthropod-borne disease exists when there are specific climate, vegetation, soil, and favorable microclimate in the places where vectors, donors, and

^a Prepared and presented by D. Roberts and L. Legters at the International Telemedicine/Disaster Medicine Conference at the Uniformed Services University of the Health Sciences, Bethesda, MD, USA from December 9-11, 1991. This paper reflects the research efforts of the following individuals: D. Roberts, S. Manguin-Gagarine, and L. Legters of USUHS, B. Wood, L. Beck, S. Whitney, M. Spanner, and J. Salute of the NASA Ames Research Center, Moffett Field, CA; M. Rodriguez, A. Ramirez, and J. Hernandez of the Malaria Research Center, Tapachula, Mexico; R. Washino and E. Rejmankova of the University of California, Davis, CA; J. Paris of the California State University, Fresno, CA; and C. Hacker of the University of Texas School of Public Health, Houston, TX.

recipients of infection take shelter (the spatial aspect). Furthermore, he noted that disease circulation takes place only *when* the environmental conditions are favorable (the seasonal aspect). Today we realize that many arthropod-borne diseases are closely associated with particular landscapes and environmental conditions. Examples of diseases that are regulated by environmental conditions include leishmaniasis, American trypanosomiasis, African trypanosomiasis, scrub typhus, Lyme disease, schistosomiasis, malaria and various arboviruses. Disease occurrence is largely regulated through control exerted by environmental conditions on the presence, abundance and activity of vector populations.

Of all the transmissible diseases, malaria continues to be the leading cause of morbidity and mortality in humans throughout the tropics, with an estimated 270 million people affected. Despite efforts to eradicate the disease, it has made a dramatic resurgence within the last 20 years. Furthermore, morbidity and mortality from malaria are at almost unprecedented levels². This conclusion is illustrated in the figure of annual parasitic indexes for the Americas (figure 1) showing that malaria rates have increased dramatically since the late 1970s.

Application of space-science technologies to study and assist in the control of malaria and other arthropod-borne diseases is the subject of a National Aeronautics and Space Administration-sponsored study³. This multidisciplinary "Malaria Project" employs expertise in remote sensing, geographic information systems, malaria epidemiology and vector ecology. The project is designed to demonstrate the use of remote sensing technologies to develop predictive models of malaria vector abundance on a local and regional scale. Organizations participating in the project include the NASA-Ames Research Center; the Uniformed Services University of the Health Sciences; the Malaria Research Center in Tapachula, Mexico; the GeoIPS lab at California State University, Fresno; the University of California at Davis; and the University of Texas.

Rationale for the project is illustrated in the relationships between models A, B and C (figure 2). Model A illustrates the linkage between the presence and abundance of malaria vectors and dynamic environmental conditions, such as rainfall, temperature and vegetation. Model B is a graphical statement to the effect that remotely sensed data can be used to reliably monitor and quantify changes in many environmental variables. Given that models A and B are true, it is reasonable to expect that remote sensing can be used to monitor environmental conditions critical to the development of malaria vector populations.

The Malaria Project was initiated in 1985. The project is being conducted in three phases. The first phase was conducted in the Central Valley of California and was designed to demonstrate "feasibility of concept." Phase II is presently being conducted in a malaria endemic area of southern Mexico; specifically in the area of Tapachula, Mexico. The Phase III locality will be ecologically similar to the Phase II site.

Phase I research was conducted on a rice-field anopheline mosquito, *Anopheles freeborni*, in the Central Valley of California. The objective of Phase I was to demonstrate the use of remote sensing to predict which rice fields would be the more important anopheline producers. Interdisciplinary field studies were conducted in 1985 and 1987, on 46 and 104 rice fields, respectively. These studies demonstrated use of remote sensing and geographic information system technologies to predict with an accuracy of 85 percent which fields would be high producers of anopheline mosquitoes 2 months before peak production occurred^{4,5}. This identification of high-producing fields was based on the detection by remotely sensed data of early developing rice fields located close to bloodmeal sources.

Following the success of Phase I research, the Phase II research program was initiated in Tapachula, Mexico. The objective of Phase II is to use remotely sensed data to develop predictive models of malaria vector abundance in time and space. The primary vector of malaria on the coastal plain in the Phase II locality is *Anopheles albimanus*.

Malaria cases occur frequently during the wet seasons in the small villages near Tapachula, Mexico. The appearance of cases is related to environmental conditions favoring the proliferation of *An. albimanus* mosquitoes. Simply stated, optimal environmental conditions consist of sufficient rain to produce an abundance of grassy, sunny pools. In addition to rainfall, environmental factors such as vegetation, topography, soil type, and temperature influence the availability of favorable breeding sites.

The presence and abundance of malaria vectors vary from time to time and area to area. This variation reflects the local environmental conditions and the ecological requirements of the anopheline mosquito. For example, *Anopheles darlingi* is the primary malaria vector in the Amazon Basin^{6,7,8}. This species flourishes during the wet season as the levels of rivers rise above their banks. The anopheline breeds in inundated areas beyond the river margins. However, as river flow is determined by rainfall upriver, vector abundance may not correlate with rainfall where the mosquitoes are actually breeding. In fact, monitoring rainfall at upriver localities would be more predictive of *An. darlingi* abundance.

In contrast, at the study site in Mexico there seem to be relationships of *An. albimanus* abundance with both local and regional patterns of rainfall. The regional influence results from the movement of rainwater to a particular site by the hydrological system. The movement occurs as surface flows (rivers) and as lateral subsurface flows (through the soil). The coastal margin within the study area is frequently flooded, is vegetationally rich and produces dense populations of *An. albimanus* during the wet season. More inland areas of mixed agriculture are at higher elevations, with better drainage. Consequently, we see reduced numbers of breeding sites per unit area in inland localities. Additionally, as we move from the wet season to the dry season, a majority of preferred habitats dry out, and breeding of the primary vector becomes restricted to permanent

bodies of water. In earlier research, we found that discriminant functions, with a variety of environmental variables, could be used to identify 60 to 100 percent of all positive and negative habitats of the local vector anophelines^{9,10}. Eventually these specific environmental determinants will be employed to predictively model the temporal and spatial distributions of *An. albimanus* populations.

Work is currently underway to use remotely sensed, hydrological, meteorological, cartographic and field surveillance data to develop a model of *An. albimanus* population dynamics within a geographic information system. Remotely sensed data will be used to identify and quantify breeding sites near villages, to update map information and, in part, to monitor the rate and direction of change in critical environmental variables. Certainly rainfall is one of the important environmental variables. Spatial and temporal patterns of rainfall are related to spatial and temporal patterns of cloud brightness as remotely sensed in the geostationary meteorological satellite imager data.¹¹

Malaria, of course, is a disease of humans. Although malaria vectors certainly occur in areas unoccupied by humans, the predictive modeling will focus on populated localities. Data on the distribution of human habitations will be included in the geographic information system and will become part of the predictive model.

In the future, we expect to see such organizations as the Center for Malaria Research in Tapachula, Mexico, routinely collecting various types of environmental data, as well as vector abundance and habitat availability data in the field. Various methods will be employed to collect the quantitative data, to include dipping for mosquito larvae, quantitative collections of resting adult mosquitoes, and area surveillance to determine the availability of breeding sites. We expect that these data, along with routinely acquired remotely sensed data, will be employed within geographic information systems to monitor and predict the temporal and spatial distribution of malaria vectors. Such models might easily become the centerpieces of local and national disease control programs.

Again, recognition of the interactions between humans, diseases, disease vectors and the environment is not new. However, we now have powerful new tools that can be employed in a more holistic approach to study and to help control the transmissible diseases. Because of strong disease-vector-human relationship, use of remote sensing and GIS technologies in the public health arena seems to be a natural alliance. As computing power decreases in cost, and increases in power and speed, remote sensing and communication technologies are likely to become increasingly important in vector-borne disease research and, ultimately, in vector-borne disease control programs.

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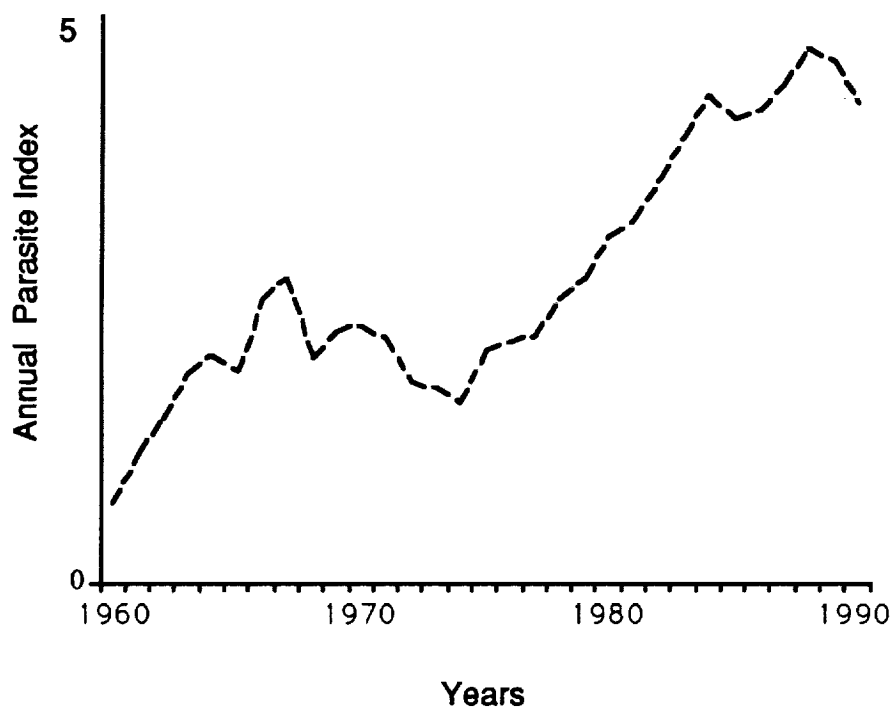


Figure 1. Annual parasite indexes of human malaria for 21 malarious countries in Central and South America.

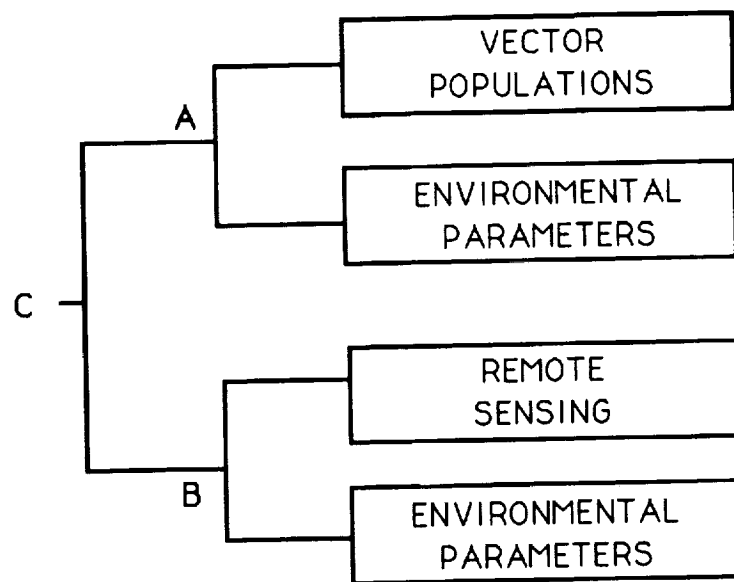


Figure 2. Conceptual model of the Biospherics Monitoring and Disease Prediction Project. Model C represents the use of remotely-sensed data to monitor and predict vector presence and abundance.

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A Telemedicine Health Care Delivery System

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The ITS system was specifically developed to address the ever widening gap between our medical care expertise and our medical care delivery system. The frustrating reality is that as our knowledge of how to diagnose and treat medical conditions has continued to advance, the system to deliver that care has remained in an embryonic stage. This has resulted in millions of people being denied their most basic health care needs.

Telemedicine utilizes an *interactive* video system integrated with biomedical telemetry that allows a physician at a base station specialty medical complex or teaching hospital to examine and treat a patient at multiple satellite locations, such as rural hospitals, ambulatory health centers, correctional institutions, facilities caring for the elderly, community hospital emergency departments, or international health facilities. Based on the interactive nature of the system design, the consulting physician at the base station can do a complete history and physical examination, as if the patient at the satellite site was sitting in the physician's office.

Integrated into the video system, and based on the requirements of the remote medical facility, are a number of diagnostic devices. The remotely controlled examination camera has a powerful zoom-focus capability that allows a *dermatologist* to examine any aspect of a patient's skin to the smallest detail. An electronic stethoscope, in conjunction with real time digital transmission of an EKG and echocardiogram, permits a *cardiologist* to do a complete cardiological examination. Specific camera adaptors and resolution capabilities enhanced by remote controlled optics provide the *ophthalmologist* at the "base station" medical facility a clear view of the retina of a patient at the referring site. An *ENT* specialist can observe a laryngoscopic examination; a *gastroenterologist* can direct an endoscopic procedure, and a *radiologist* can interpret any type of X-ray examination, including MRI, CAT scan, or ultrasound. A pathologist, utilizing the telemicroscopic adaptor, can examine a frozen section or bone marrow slide, and a *surgeon* or *gynecologist* can participate in a laparoscopic procedure.

A *thoracic surgeon* can instruct a surgeon in a small community hospital to do thoracoscopic surgery, a *urologist* can view a cystoscopic procedure, and an *orthopedist* can direct arthroscopic surgery. To ensure the widespread availability of state-of-the-art trauma care, a

trauma surgeon will be able to examine a trauma victim at a remote location and instruct local emergency physicians as to necessary surgical procedures and resuscitative measures.

A computer-controlled switching matrix allows for networking of the central base station to multiple remote locations; if desired, a video recorder can provide retention of consultations for record keeping, quality assessment and teaching purposes. A high speed, plain paper facsimile affords immediate and efficient document transfer (patient records, prescriptions, consultation notes, references from a PC-based data base, etc.). Freeze frame capability allows any image projected at either the base station or peripheral site to be "frozen" and sent as a slide to the other site. With a special "menu" provided by the control panel, X-rays, EKGs, or slides can be annotated with an electronic pen. An X-ray can be viewed on one video monitor while the patient examination is occurring on a second monitor.

This interactive telemedical system has introduced a unique *continuing medical education* experience for the primary health care provider. Since the specialist at the hospital base station can evaluate the patient at the same time that the primary care physician does, the primary care physician is provided an immediate interactive educational input that he would not have if he referred the patient to that specialist outside the satellite facility. As a result of this simultaneous interactive consultation between primary care physician and specialist, the educational level of that primary care physician is improved, resulting in the ability to handle more complex problems and effect more appropriate specialty utilization. By providing the comprehensive physician expertise available at a major medical center, the ITS system ensures that the latest advances in diagnosis and treatment are made available to the patient. Additionally, since the patient does not need to be transported to the specialist, he can be treated sooner and at a less serious stage of the disease process. Specialty availability plus immediate access means improved *quality care*.

The ITS system, by reducing the need to transfer a patient to a distant medical facility, maintains *continuity of care* between the patient and the primary care physician. In addition, if a patient does need to be transferred, the primary care physician can be updated on a daily basis by the treating physician at the base station referral site over the telemedicine link. Once the patient is discharged from the referral medical facility, the specialist's ambulatory follow-up care of the patient is also facilitated utilizing the ITS system without the inconvenience of distant travel by the patient.

The cost of a consult over the interactive system is equivalent to the cost of an EKG or chest X-ray! Additionally, by decreasing the need to transfer patients, for example from a rural hospital to the urban center for consultation, there are cost reductions as a result of the differential costs between the two facilities as well as avoiding transportation expenses and requiring less time away from work. But as overall health care costs are reduced, the revenue generated at the satellite and base station facilities is enhanced. By decreasing the need to send patients to other locations

for care, they stay in the rural hospital bed where both the hospital and primary care physician can bill for the additional patient stay. Although total referrals from satellite facilities requiring transport to a medical center are reduced, referrals that do occur tend to be sent to the base station facility, a result of the networking that has been established.

The base station space requirements are equivalent to the square footage of a physician's office. The satellite site requires space equal to a physician's examination room. The system is compatible with multiple types of communication systems (telephone line, cable, microwave, and satellite). Both the base station and satellite site equipment is easy to install, and can be easily relocated, if the original site location needs to be changed. The system is also adaptable to a mobile configuration in that the equipment can be placed in a small van and taken to multiple satellite sites. This flexibility allows a satellite site to have access to the specialty medical center on an "as needed basis" and the distance capacity of the system allows a cardiologist in Boston to examine the heart of a patient in Alaska, Maine, or "around the corner."

The ITS telemedical system thus provides *immediate access* to quality health care. It *resolves* the problems inherent in our existing system of: 1) geographic or socioeconomic isolation for the patient; 2) professional isolation for the physician; 3) escalating costs; 4) inappropriate utilization; 5) loss of continuity; and 6) ineffective CME.

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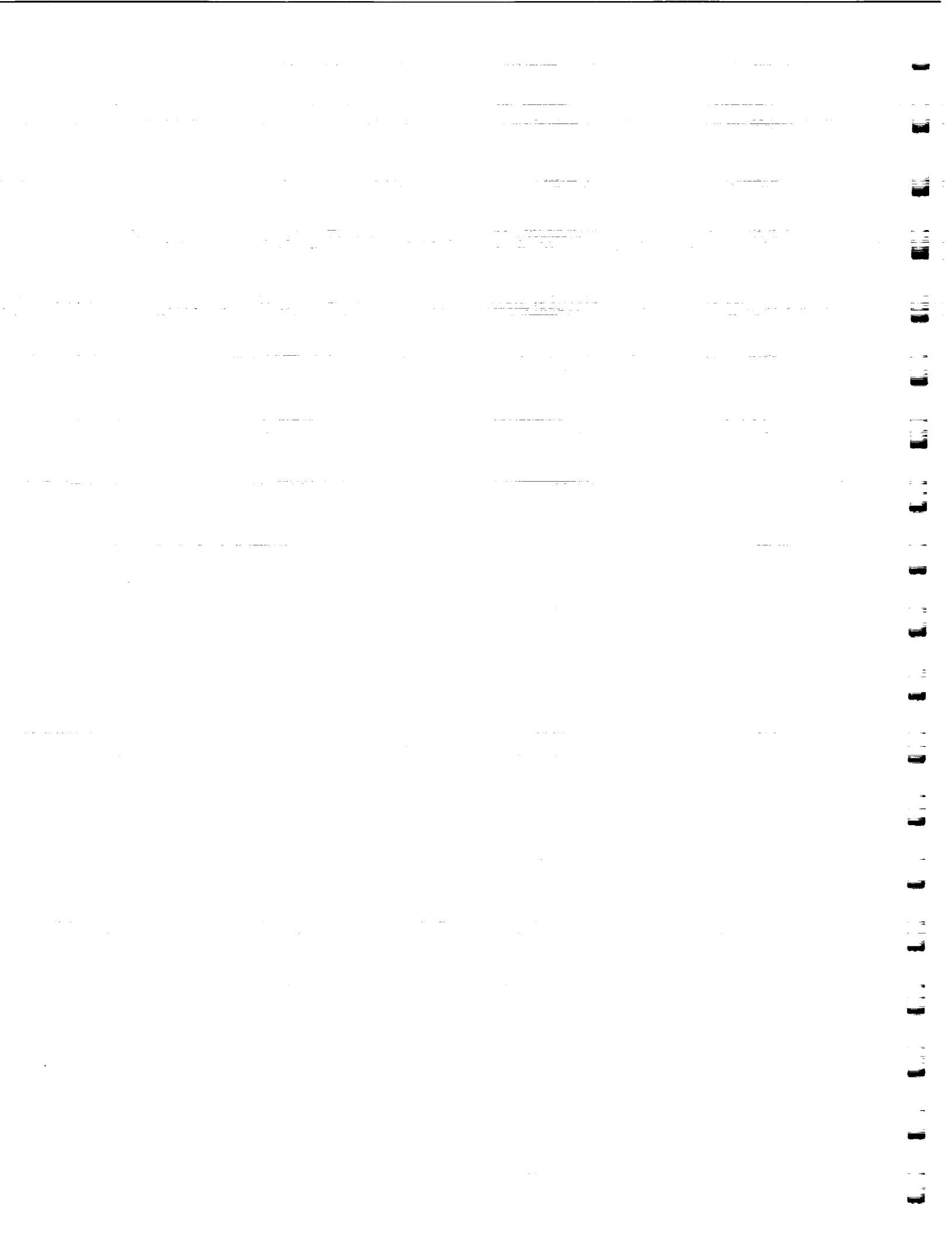
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**Communications Infrastructure Requirements for
Telemedicine/Telehealth
in the Context of Planning for and Responding to Natural Disasters:
Considering the Need for Shared Regional Networks**

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INTRODUCTION

During the course of recent years the frequency and magnitude of major disasters—of natural, technological, or ecological origin—have made the world community dramatically aware of the immense losses of human life and economic resources that are caused regularly by such calamities. Between 1967 and 1987 nearly 3 million lives were lost and property damage of \$25-100 billion resulted from natural disasters that adversely affected more than 800 million people.

Particularly hard hit are developing countries, for whom the magnitude of disasters frequently outstrips the ability of the society to cope with them.

A single hazardous event can destroy social and economic infrastructure, including communications, that may have taken years to develop and upon whose vitality local and national economies depend. Frequently in developing countries the capacities of these infrastructures are strained to manage even the most basic of social and economic development programs in normal times, and a single disaster can severely disrupt the community lifelines that provide food distribution, water supply, health care, waste disposal, and communication locally and with the rest of the world.

In order to realize their fullest potential, developing countries need a sustained period of social and economic growth. Major impediments to sustained growth are the disasters which often result in an affected country shifting its economic policies to sustain the energy required to cope with disaster response and subsequent reconstruction. These shifts can intensify a country's financial imbalances and deplete available resources.

In many cases this situation can be prevented, and the recent trend in disaster management has been to emphasize the importance of preparedness and mitigation as a means of prevention. It is believed that effective prevention, mitigation, and preparedness will reduce the need to respond. For example, accurate and timely warning of an impending disaster can save life and property. Of

course, there are cases when warning is not possible or the magnitude of a disaster overcomes even the most prepared community.

In these cases a system is needed, preferably one that is already in place, to respond to relief requirements, particularly the delivery of medical care.

There is no generic telecommunications infrastructure appropriate for the variety of applications in medical care and disaster management. With the time I have today I will offer my opinion of the need to integrate "telemedicine/telehealth" into shared regional disaster management telecommunications networks. I will focus on the development of infrastructure designed to serve the needs of disaster prone regions of the developing world. Such shared networks are currently nonexistent, but can be hoped for in the future.

In the broad field of disaster management, the value of interactive real-time telecommunications links between and among meteorologists and volcanologists has long been appreciated and, rudimentary though they might be in technical terms, networks serve their daily needs of preparedness, prevention, and mitigation. Available infrastructure or ad hoc constructions also enable these managers to operate on short notice in relief efforts after a disaster.

These are, of course, different applications from those employed by health care workers and specialists in disaster medicine, but the technologies required, generally speaking, are the same and could be shared. The medical community has been slow to integrate telemedicine/telehealth into standard procedure and particularly so in response to disasters.

There is, of course, no single reason for this, but I suggest that the complications are rooted in the difficulties associated with inter-institutional and interdisciplinary coordination. With other technologies, their application frequently yields a response directly to the professional. With telemedicine/telehealth, sharing of information between or among two or more people is inherent in the application. This, then, introduces a number of issues that necessarily involve more than the individual practitioner. These issues include protocols for delivering (and receiving) care and new approaches to billing and liability and will involve patients, physicians, hospitals, insurers, and others. Even within a single institution telemedicine/telehealth is up against the same gauntlet.

Use of data, audio and video technologies in acute and chronic care has been demonstrated in rehabilitation medicine, reconstructive surgery, burn management, sanitation and epidemiology, preventive medicine, and post-traumatic stress, to name a few. These demonstrations have typically been of short duration, though, and telemedicine/telehealth as a routine practice has been infrequently institutionalized. Further, there has been scarce validation of telemedical systems in the variety of settings and situations required to satisfy the cautious, and sometimes skeptical, medical community of physicians, hospital administrators, and insurance providers.

In urban centers of countries with highly developed economies (locations that provide the economic stimulus frequently needed to motivate the development of new technologies) some

telemedicine/telehealth systems can be found operating. But in most remote areas of these countries, and in developing countries in general, such networks cannot be found.

Though it would be difficult to overemphasize the difficulties associated with the lack of access to technology, both developed and developing communities share the sometimes greater challenge of working out the regulatory, institutional, and professional protocols for application of those technologies that *are* available. In short, the challenge in applying telecommunications technology to medicine, and health care in general, is frequently not a question of the suitability, or even availability, of the technologies themselves, but the development of the relationships among the users.

For example, it could be argued that the reason why a telecommunications network that could be shared by disaster managers has not been developed is because the potential users have not decided among themselves that such a network should be developed. It could be further argued that the resources that are currently available within each region—from the governments and private sector of the region's countries, and from international agencies, consortia, and donor countries—are sufficient to cover the expenses associated with such a network if the costs are shared by all.

Certainly there is need. Though not frequently addressed in terms of integrated multi-sector network, this need is commonly perceived by disaster managers specializing in a number of different sectors and phases of disaster management. The technology is available and, arguably, affordable if the burden is shared among a number users (read beneficiaries).

SHARED NETWORK CONCEPT

To be most effective, a shared disaster management telecommunications network should be viewed in a multi-sectorial context. Although it is important to understand the respective interests of each sector, funding and political impetus to the programs will likely be stronger if they can be derived from a coalition of broad public and private sector support.

Disaster managers have long envisioned the value of timely communications, yet resources to establish and sustain the requisite infrastructures have been inadequately allocated in comparison with demand for their service. Financing appropriate technology development to serve the needs of countries prone to disaster would be less burdensome if these technologies could be seen as basic infrastructure requirements. Costs could then be shared by all sectors of the nation and region, and protocols developed for shared access to—and use of—technology resources. A necessary challenge would then be to design these protocols so that they permit international cooperation during times of need.

Post-disaster analysis has frequently shown that lack of communications links able to provide hazard warnings have resulted in catastrophic loss that might have been avoided with adequate warning. Further, inadequate or nonexistent communications links following a disaster can delay relief efforts and medical care, and can cause confusion and overlap in response.

A network that could serve a number of users with differing requirements would have at least four basic components: user workstations (of various sizes and peripheral apparatus), domestic communications links between user workstations and the satellite earthstation, a satellite earthstation, and the international satellite space segment. This network should also be operational and in use (and tested) frequently to ensure its function when needed.

Workstations. In this case the term workstation refers to the terminus (or origination point) of the information network. In the field, workstations are envisioned (depending on need and funding) as macro- or micro-computer-based decision support systems capable of transmitting required information as data, voice, fax, and still frame video. Their primary functions would be to:

- Permit the storage and manipulation of basic information which is routinely collected and maintained concerning availability and location of fire, police and medical resources; evacuation and transportation routes for emergency vehicles; supplies such as food, water, medicines, cots, and blankets; shelter; and medical data, prepared according to agreed upon formats and protocols; and to
- Receive and transmit dynamic, real-time information regarding damage and casualty assessments, patient treatment and evacuation, requirements for medicines and relief support, detection and warning of secondary (i.e., aftershock) disaster threats, etc.

Depending on the need and resources available, these workstations could be adaptable to include (or permanently equipped for) compressed video, and full-motion video transmission.

Domestic Telecommunications Link Between Workstation and Uplink. One of the benefits of a shared network is the reduction of cost. This cost savings is realized, in large part, by the sharing the financial burden of purchase, installation, and maintenance of major resources such as satellite earthstations capable of transmitting and receiving information via international satellites.

Of necessity, then, the earthstations in this network would be located at either one user's site, for example a regional or tertiary-level hospital capable of coordinating a broad range of medical response activity, or at telecommunications facilities that are a part of a country's communications infrastructure. This necessitates the selection of earthstation managers who are willing and capable of working cooperatively with other users of different institutions, agencies, and disciplines. It also requires the establishment of a link between the earthstation and all workstations that are to be a part of the network.

The links that connect these workstations must be resilient to the types of disasters that frequent the area in which they are expected to operate. Ideally they should be redundant and mobile or transportable. And they must also be, by necessity, affordable.

Domestic options, which must be considered on a case-by-case basis, include: HF, UHF and VHF radio, cellular radio, microwave, and satellite.

Although each workstation or cluster of workstations will be able to operate using its own software programs, the technical protocols for transmission of information between the satellite earthstations and user workstations must be compatible.

Satellite Earthstations. A form of VSAT (Very Small Aperture Terminal) network capable of carrying data and voice (and facsimile) traffic is envisioned for the proposed network. VSAT technology permits use of small earthstations which, in a network consisting of several stations, can result in a system that is lower in cost and easier to maintain than its terrestrial equivalent. Further, and importantly, a VSAT network would be more reliable and resilient to conditions common during severe disasters. For example, if one site is damaged in a terrestrial network, it is typically the case that all sites in the chain from that point on are out of business too. Whereas in a VSAT network, if one site goes down other sites are not necessarily affected because of that casualty. Another advantage of a VSAT network is the ease with which additional sites can be added at any time.

The flexibility of a VSAT network also permits a "mesh" network configuration where any site within the network can originate and receive transmissions at any time.

With the requirement of multiple and changing origination points within the network, and because of the small size of VSATs, there is a requirement for a "hub," or master earthstation in a VSAT network. Transmissions from any user within the network are sent to the satellite and received by the master earthstation located anywhere within the footprint of the satellite. The master earthstation then retransmits the information, at greater power, to the satellite for distribution to the other VSATs. This is referred to as a "double hop" and, though the process may sound complex, it is transparent to the user.

Satellite Space Segment. Because of the size and geographical diversity of the regions of the world, a satellite-based network is envisioned and briefly described earlier. Although the amount of time leased on the satellite will be determined by the amount of traffic between the various users, assuming the selection of one satellite that covers an entire region there is no limitation imposed by the satellite on the number of users. Further, assuming that adequate space segment has been leased, any number of groundstations can access the system without additional charge for satellite time. It is also the case that, with sufficient bandwidth and appropriate technical architecture, the system can be used by a number of users simultaneously, each without interfering with the other.

COORDINATION OF INTERNATIONAL EFFORT

Finally, and in brief, the planning and implementation of regional multi-hazard networks, and schemes for their funding, must involve the national, regional and international users in a process that would lead to the identification of a network manager or coordinator.

Because of the international consultation and negotiation that would be required, coordination of technical, programmatic, and funding is a role that might best be played by organizations such as the Office of the United Nations Disaster Relief Coordinator (UNDRO) and the World Health Organization (WHO). Other organizations that might be involved in the process include the International Telecommunication Union (ITU), the World Meteorological Organization (WMO), the United Nations Development Programme (UNDP), and the United Nations High Commission for Refugees (UNHCR).

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International Disaster Research

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No existing telecommunications system can be expected to provide strategy and tactics appropriate to the complex, many faceted problem of disaster. It is the ultimate in wishful thinking to expect systems, hardware, and software designed for one purpose or region of the globe to be magically applicable to these massive events which destroy or damage human life, property, and societal organizations.

Despite the exciting capabilities of space, communications, remote sensing, and the miracles of modern medicine, complete turnkey transfers to the disaster problem do not make the fit, and cannot be expected to do so.

In 1980, a Presidential team, assigned the mission of exploring disaster response within the U.S. Federal Government, encountered an unanticipated obstacle: disaster was essentially undefined. Its life cycle was incompletely understood and management, therefore, largely ad hoc, lacking the precision of other areas of science and technology. In the absence of a scientifically based paradigm of disaster, there can be no measure of cost effectiveness, optimum design of manpower structure, or precise application of any technology. These problems spawned a 10-year, multidisciplinary study designed to define the origins, anatomy, and necessary management techniques for catastrophes, which was conducted at the Center for Strategic and International Studies with the encouragement and assistance of the Uniformed Services University of the Health Sciences.

The design of the study necessarily reflects interests and expertise in disaster medicine, emergency medicine, telecommunications, computer communications, and forensic sciences. The study owes a great deal to Dr. Prem Gupta, Managing Director of CMC Limited, an Indian governmental corporation, and the members of Dr. Gupta's staff, who generously contributed their time and knowledge, to Dr. Glen McWright, a Senior Forensic Scientist who served with the U.S. Federal Bureau of Investigation, and to Dr. S. Ramani, Senior Research Scientist with the Indian National Centre for Software Development. Another great contribution to this study was the leadership of Dr. Gupta and Dr. Farouk Kamoun, President of Centre National de l'Informatique in Tunisia, in bringing to bear the knowledge of 127 scientific and governmental specialists of the industrialized and developing nations.

Research methodologies were constructed: the phenomena of disasters were examined, along with case histories of 100 large-scale destructive events which had occurred in the 20th century. Viewed through the investigatory lens of the many disciplines applicable to these catastrophic events, a surprising number of commonalities slowly became apparent. Within the parameters established by a working definition, applicable to both sudden and "creeping" disasters, a common, temporal model was identified. The definition which we ultimately used: was any permutation of human injury, property damage, the overwhelming of local resources and the ultimate disruption of the fabric of society. We were surprised to find that the common elements occurred not only in natural but in industrial/technological and conflict disasters. A taxonomy was developed which elaborated on these major categories of disaster. It soon became evident that examination of all three of these major categories of disaster were necessary for our study, and that economy and cost-effectiveness in response to disaster lay in including all major etiologies of disaster. No matter how comfortable a study limited exclusively to natural disasters is, attractive because of its apolitical and "sanitized" nature, such studies appeared to us to be fragmentary and unscientific. Indeed, a common, temporal model, a template if you will, evolved.

The phases of a temporal model of disaster include

- A quiescent phase—A period of time in which the causative factors ebb and flow harmlessly until such time as the mixture assembles, often randomly, into a critical and inevitable disaster pattern
- A prodromal phase—The point at which the inevitability and criticality of the pattern becomes clear and some predictions become possible about the timing of the oncoming catastrophe
- A disaster phase—The time of cataclysm during which acute damage to human beings, to property and to the fabric of society occurs
- A recovery phase—The repair period during which normal sociopolitical relationships are restored, people are healed, and the destruction of property repaired.

From the standpoint of the construction of data banks, remote sensory surveillance, telecommunications, and management, it is convenient to divide networks into strategic and tactical. The ongoing role of networks in monitoring the behavior and emergence of disasters from their pre-cataclysmic events through the completion of recovery is perceived as a permanent strategic function. It consists of remote sensing, global communications networks, and data banks. The sensing and monitoring needs of the disaster phenomena utilize space, atmospheric, ground surface, underground surface, and undersea areas on a continuous and global basis. It clearly is an activity to be carried out by a consortium of nations, or by the United Nations itself. From the prodromal stage of warning, to the actual management of erupting disaster, data from the

strategic network, including appropriate consultation, should be dedicated to mobile apparatus at the beck and call of the on-site disaster manager. The disaster manager in control of tactical deployment of men and resource allocation is essentially a temporary local area network (LAN). A purposeful, tactical network will provide long term benefits to future disasters by input of quantified data. In studying our 100 cases, we quantified mortality, morbidity and property damage. Clearly this is an activity which extends into the recovery phase.

The need for custom-tailoring of tactical communications systems presently available and necessary for real time command, control, communication, search and rescue, management of the wounded, population evacuation, and other requirements of acute disaster management became evident.

Twentieth century response to the sick and injured of non-disaster injury is almost universally a labor intensive, medical procedure. When preparing for massive numbers of casualties, search and rescue and emergency resuscitation (reanimatology) must be carried out initially by first responders at the site, and by local people, who are themselves uninjured and who can engage in search and rescue. A body of knowledge is slowly being accumulated which can form the essential data bank to be used as a resource for the austere measures to be carried out by essentially non-medical echelons of rescuers. Instruction for reanimatology can be provided to remote areas via the tactical LAN.

CASE ANALYSIS

Lessons learned after thousands of hours of air and other travel to industrialized and developing nations revealed the special and counterdistinctive needs of the many cultures, religions, legal systems, as well as the political goals and constraints demanded by regional disaster management communications. The values derived from working alongside our colleagues in the communications and medical establishments of Western Europe and of developing areas in Asia are emphasized.

At about 1:00 a.m. on December 2, 1984, a typical cascade of unhappy events occurred at the Union Carbide Plant near the community of Bhopal in Madhya Pradesh, India. A few lessons in the provision of both strategic and tactical telecommunications stand out at the cost of 4,000 deaths, and approximately 365,000 permanently injured victims. From a strategic standpoint, the area disaster managers were not able to access data on the pathophysiology of methyl isocyanate. In discussions with Mr. I. Sathyam, the senior civil servant in charge of the long term recovery of the area, it seemed evident that a LAN, whose sensors could measure the toxic emission at its onset, and combine that information with the prevailing wind at that moment, could have automatically provided, through permanent loudspeakers, the need to evacuate the area, and the

route of evacuation. We have estimated that had such a system been in place, and been able to provide emergency evacuation instructions in the 14 languages of India, the morbidity and mortality might have been reduced to 10 percent of the awful total. Armed with that information, several of us, working with the computer and communications scientists in their own offices, devised just such an LAN. In collaboration with local experts, we have devised other telecommunications system which we hope will be effective. With the energetic cooperation of Air Vice Marshal John Lessels, the former Director General of the Australian Natural Disaster Organization, and the staff of the Australian Counter Disaster College, we have devised combative measures against some of Australia's major catastrophic threats.

The major capitols of the world are not without numerous conflict disasters. In working with first responders from the police, fire and medical agencies of New York and London, and the GSD-9 officers of what is now Berlin, we have learned a great deal from the communications systems. They supply models for global strategic and tactical networks.

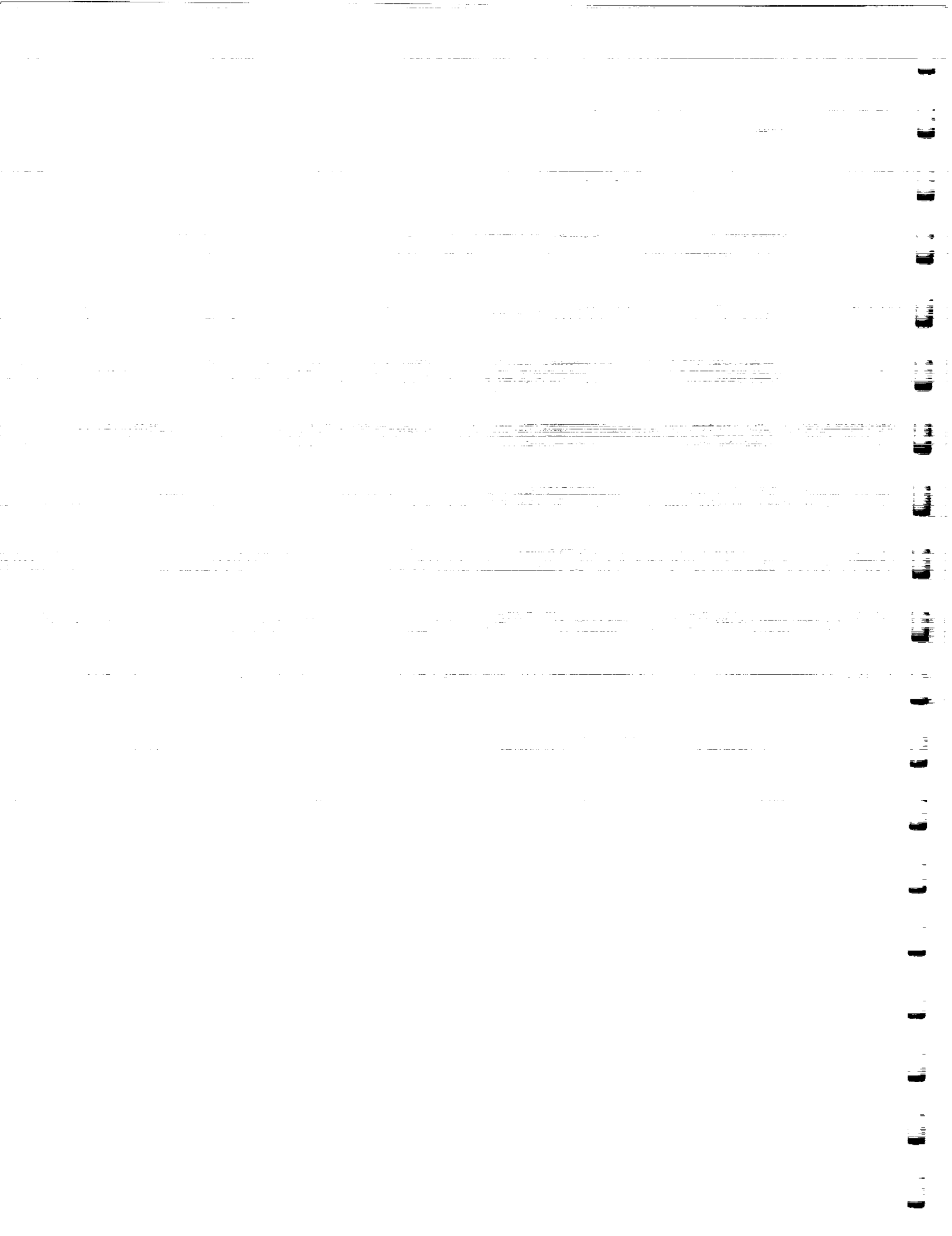
Communications networks are the routes of international disaster diplomacy. The success of international disaster research and management hinges on the specialized sensitive application of traditional manual and high technological systems.

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Medical Care Delivery in the U.S. Space Program

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The stated goal of this meeting is to examine the use of telemedicine in disaster management, public health, and remote health care. NASA, for obvious reasons, has a vested interest in providing health care to crews in remote environments. NASA has unique requirements for telemedicine support, in that our flight crews conduct their job in the most remote of all work environments. Compounding the degree of remoteness are other environmental concerns, including confinement, lack of atmosphere, spaceflight physiological deconditioning, and radiation exposure, to name a few.

In-flight medical care is a key component in the overall medical support for missions, which also includes extensive medical screening during selection, preventive medical programs for the astronauts, and in-flight medical monitoring and consultation. This latter element constitutes the telemedicine aspect of crew health care. Due to the extreme resource constraints present in spacecraft (defined here as crew time, weight, volume, and power), all medical support systems must be rigorously justified and directly related to the perceived risk of a given mission.

The level of in-flight resources dedicated to medical care is determined by the perceived risk of a given mission, which in turn is related to mission duration, planned crew activities, and length of time required for return to definitive medical care facilities. In the Mercury Program, although the perceived risk of medical problems was very high, the medical kit was very small and rudimentary, containing only four medications. This was in keeping with the extreme volume constraints, and the ability to effect a rapid return to Earth. In-flight medical care capability was subsequently expanded during the Gemini and Apollo Programs in response to longer mission duration and the prospect of conducting operations away from the relative safety of low Earth orbit. For the Apollo Program, medical kits were included in both the command module and the lunar module. While there were no major medical problems during the approximately 7500 hours of flight time that accumulated during Apollo, the initial cases of space motion sickness (SMS) were observed, potentially serious cardiac arrhythmias were observed during Apollo 15, and near-catastrophe was averted during the Apollo 13 mission, when flight control teams managed to nurse the crippled spacecraft back to Earth. This latter mission highlighted the fact that life support system failures or compromise can threaten crew health. The spectrum of medical illness or injury that might result from life support degradation or failure should therefore be considered in the

design of in-flight medical care systems. It follows logically that real-time analysis of atmospheric contaminants in a spacecraft will be necessary to diagnose the potential medical consequences.

Since 1981, there have been four Space Shuttle missions lasting from 8-10 days, each mission carrying 4-7 crewmembers. Although some astronauts have had minor illness in flight, there have been no major medical incidents. Perhaps the most vexing problem that we have had to cope with is space motion sickness, which causes nausea and vomiting, usually during the first 72 hours of flight, after which there is complete remission.

In spite of our good record in space, we have an active medical program to ensure care should it become necessary in flight. The major facets of the program include the Health Stabilization Program (HSP), crew medical training, the Shuttle Orbiter Medical System Kit (SOMS), Contaminant Cleanup Kit (CCK), the Bends Treatment Apparatus (BTA), and routine private medical conferences on a daily basis.

The medical conferences occur on a routine, scheduled basis, allowing the crew surgeon to communicate with the crew medical officer (CMO). Should an urgent medical concern arise, the CMO can request a medical conference at any time. The flight surgeon in turn has a host of medical specialists available if needed for specialty consultation. In-flight health care delivery capability is limited by the contents of the medical kit and the skills of the CMO. Since approximately 10 percent of the U.S. astronauts are physicians, medical care capability, in terms of the CMO, can vary substantially.

The HSP requires that all astronauts, beginning 1 week prior to flight, have limited contact with other individuals in order to reduce the risk of exposure to any communicable disease. The HSP was first initiated during Apollo and has been credited with significantly reducing pre-flight and in-flight illness. In addition, two members of the crew (who may or may not be physicians) are designated CMOs. They receive extensive pre-flight training in basic medical diagnostics and therapeutics, including suturing and IV techniques, medical procedures, and CPR. The other crewmembers also receive some training in medical procedures as well as CPR in order to back up the CMOs.

The medical instruments, supplies, and medications are carried in the SOMS Kit and CCK. These kits weigh approximately 20 pounds and easily fit into one Shuttle middeck locker. They contain basic medications including topicals, injectables, and an IV fluid administration set. There are also bandages and dressings as well as patient restraints, rescuer restraints, and a resuscitator. The CCK contains gloves, goggles, and masks to be used in the event of toxic spills.

Because EVA is sometimes necessary during Shuttle missions, an Operational Bioinstrumentation System (OBS) is provided so that physicians on the ground can monitor the ECG, heart rate, respiration, and temperature of the EVA crewmember. In the event of bends, a

BTA can be attached to the pressure suit, allowing an increase of pressure of 8 psi. Fortunately, there have been no bends incidents reported in flight during the U.S. Space Program.

In summary, the paucity of significant medical incidents on Shuttle flights has placed few demands on the SOMS/CCK system. However, should there be a need, we believe trained CMOs, utilizing the SOMS kit and CCK, could provide reasonable comprehensive medical care allowing temporization of any major medical problems until the Shuttle could deorbit and land.

NASA's involvement in telemedicine began as an outgrowth of the need for biomedical monitoring of flight crews. From this beginning in the 1960s, several terrestrial applications evolved as testbeds for NASA technology. The first of these applications involved use of a NASA ATS-1 satellite to provide medical consultation to remote Alaskan villages. Between 1973 and 1977, a telemedicine demonstration program known as STARPAHC (Space Technology Applied to Rural Papago Advanced Health Care) was conducted on the Papago Indian Reservation in Arizona. This activity, sponsored by NASA and the Indian Health Service, was the most comprehensive application of space technology to remote health care delivery of that era. This system was designed to improve the quality of health care to remote areas by utilizing a mobile health clinic with advanced health care equipment. The Mobile Health Unit (MHU) was staffed with a physician's assistant and a laboratory technician. The physician's assistant would administer health care to patients under the direct supervision of physicians, who were located at the Health Services Support Control Center (HSSCC) in the city of Sells. If specialty consultation was required, a dedicated console at the Indian Health Hospital in Phoenix allowed access to specialist physicians.

The level of clinical care allowed by mobile health units was comparable to that of a fixed clinic. Access to computerized medical records by means of telemetry allowed the physician's assistant access to pertinent clinical information as needed. Clinical chemistry, urine analysis, and X-rays could be accomplished and transmitted to the monitoring physician. In addition to two-way audio, color TV cameras transmitted live images to the physician consoles, allowing the physician to remotely control the TV cameras. If necessary, visualization of a body orifice, such as the throat, could be accomplished by means of a patient viewing microscope. Transmission of X-ray films was done by means of slow-scan video.

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Use of Satellite Telecommunications for Telemedicine

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DEAR COLLEAGUES,

The use of space telecommunications facilities in the interests of medicine (in a broad sense) should establish a reliable and timely connection between the specialists involved and access—for each of them—to information sources they need.

Since a certain global-scale program should be implemented for this goal to be achieved, one of the top-priority tasks is to determine appropriate orbital facilities for telecommunications as well as appropriate areas and countries for them, outlining the territories where portable data receive/transport records can be placed and stations that are cheap and simple enough to operate can be stored.

Naturally this work should begin only after an appropriate conception is developed, as well as the technological optimization of the exchange procedure, of hardware compatibility, and after demonstration experiments are conducted, mainly by the U.S.A. and the U.S.S.R. Along with confirming—in practice—the possibility of implementing the scheme developed, the above experiments would also be of political significance: this would be an illustration of a joint humane work between the East and the West on the peaceful use of outer space and in the interests of all other states, which could be an impetus to other developed countries to join the program.

Eventually the satellite telecommunications system should encourage health workers to unite in a world community on the basis of a regular and efficient information exchange with the goal of protecting the health of man and the peace of Earth. This long-term goal could only be achieved by gradually removing differences in the domain of medical education and information in different regions over the globe, by providing a possibility of rapid and coordinated access to the information on medical problems of interest on the global scale, as well as by coordinating the discussion and solution of all problems associated with the development and progress of the satellite telecommunications system.

The satellite telecommunications system under development should obviously be global in terms of its coverage, with opportunities to involve users from any region; it should be a sufficiently flexible system, permitting the necessary information to be obtained in time to allow

decisions to be taken without impeding the solution of a problem; it should also be easily accessible, cheap, and simple from the viewpoint of a wide involvement of potential users.

Since the system should be developed with its prospects and growing number of potential users in view, then, in our opinion, all approved and implemented technical solutions should obey the priority development concept, which will help considerably to increase the life cycle of the system and also improve the system with minimal expenditures. We believe that the system should operate in two modes: 1) information servicing; 2) urgent medical consultation and assistance.

Besides, if the information servicing mode mainly implies the absence of stringent requirements on how prompt the system servicing is, the urgent consultation and assistance mode should be insured by the system's functioning, at least in certain types of operations, in real time. It goes without saying, of course, that normal consultation can be provided without specific requirements for prompt servicing.

In the context of the tragic events that have occurred in recent years on the planet, in particular in the U.S.S.R., especially the tragedy in Armenia, primary emphasis should be given to the mode of urgent international medical aid and consultation.

In our view, the analysis of events in Armenia, especially the analysis of the first stage of providing international medical assistance and the removal of aftereffects, makes the world community face the special problem of extraordinary calamities in any region of the globe, to be more exact, the problem of joint eradication of the aftereffects of these tragedies.

Unfortunately, by now the scientific foundations of organized rescue (especially international rescue) have not been developed enough for extreme situations; there has never been an organizationally well-developed engineering system relying upon advanced international expertise and incorporating at the more recent scientific and technological achievements, in particular those in the sphere of data acquisition and processing systems, and preparation of respective decisions.

The tragic events in our country (Georgia, Tadjikistan, Bashkirtostan) have confirmed the necessity of developing such a system: simple enough with a high factor of readiness for use; sufficiently versatile and adaptive to a wide range of possible extreme situations; applying a developed system of telecommunications, including space communication.

At present, different countries have different approaches to problems associated with providing international assistance in extreme calamities and eradicating the aftereffects of such calamities.

Obviously, the top-priority problem here is the exchange of results and the systematization of joint, coordinated, international actions in similar situations. We think that these activities should undoubtedly be associated with the results of similar trends of activities within such international organizations as the World Health Organization and the International Red Cross.

In all the cases mentioned above, a global system of satellite telecommunications is, in our opinion, a *sine qua non* means for informational interaction having an urgent assistance mode which still has no alternative.

There are still some problems along this road, but from the viewpoint of today's situation, all of them can be solved. The first necessity is a decision of coordinated activities approved by the U.S.S.R. and the U.S.A., which can remove all problematic questions of a juridical, organizational and financial nature.

An optimal structure of a dynamic organization is needed which could use in its operation—at the initial stage—the instruments now under development at least for some countries.

The foundations of the satellite telecommunications system under development should be scientifically analyzed in terms of systems approach, taking into account the component, structural, functional, integration and communication aspects. Here comprehensive consideration should also be given to all kinds of support: hardware, algorithms, software, information, organization, etc.

In our case, special attention could be given to the aspect of the system's evolutionary development, since individual fragments that can be used have been developed independently and autonomously, whereas they could acquire a new quality within the system discussed.

At the initial stage of the activity in the U.S.S.R. and U.S.A. the possibilities exist for efficiently using the systems developed earlier for other purposes, which still have some reserve. In particular, the use of the capabilities of the INTER-SPUTNIK and INTELSAT systems should make it possible to organize in the agreed time the regular exchange (for example, once per week) of news in medicine employing the principle of TV news exchange, to conduct planned or, if required, special TV bridges between the leaders of a program, or to do other procedures. In this case there are no technical problems, but it is necessary to solve organizational problems. The experience gained during operations with the INTELSAT ground-based station installed in Yerevan and used for performing joint consultations and TV bridges between the U.S.S.R. and U.S.A. conclusively confirmed the above considerations.

The designed mode of teleconferences using the Soviet space segment (GORIZONT spacecraft), the NAUKA Soviet ground-based station, and the U.S.A.-made compressed video permits TV bridges to be conducted regularly in the interests of the U.S.S.R. and the U.S.A. In principle, there is a possibility of using the COSPAS system in the interest of the program "Space for Health." This program envisions that the staff of medical offices in the potentially hazardous regions (in the sense of epidemic) should be supplied with emergency transmitters with information of the type "character and type of accident, hazard, epidemic, the size of calamity (the number of defeated people, the size of territory)" and so on.

Such transmitters could be used in medical offices of provincial towns in hazardous regions, which, if required, should be given to physicians sent to a region affected by calamity.

In the case of the agreement with the administration of the COSPAS system and, possibly, with the COSPAS-SARSAT system, emergency information of a medical nature could be quickly (within hours) transmitted to the appropriate medical centers for analysis and the organization of required efforts.

In the opinion of specialists at the initial stage about 500 modified portable personal transmitters could be put into operation with a keyboard to type an appropriate code that could work with 50 transmitters, not higher, in a zone with a radius of 2500 km.

If the user of the transmitter has the receiver/processor of signals installed which can operate at an AES transmitter frequency, used to receive and decode a digital flow with a rate of 2.4 Kbit/s, it is possible to organize the duplex exchange of information with the center using the principle of the packet-switched data communication with free access. For this option, however, it is necessary to develop and install on board the artificial Earth satellite an additional transmitter and appropriate antenna.

At present, it is planned to make the exchange by digital data flows, voice information, the organization of TV reporting and TV conferencing in the mode of compressed video using the NAUKA small portable modular station and its modifications designed in the U.S.S.R.

It is, however, only single problems, a certain backlog on the problem which can be solved using a multifunctional satellite telecommunication system whose base can be illustrated by the interesting presentation of Academician M. F. Reshetnev.

Proceeding from the conceptual viewpoint to certain problems of using satellite telecommunication systems in the interest of emergency medicine to particular applications, we would like to inform the conference about the experience in the design of the transcontinental satellite communication system with the compression TV mode in the interests of teleconferences over a mid-rate channel.

A possible technical base for the development of such a system is the presence of Soviet GORIZONTs on a stationary orbit, the NAUKA ground-based station, and American sets of compression TV for their use in the mode of teleconferences (appropriate slides are demonstrated). The GORIZONT spacecraft at the point of sight 14° W (STATSIONAR-4) ensures the coverage zone from the East Coast of North America to the Urals in our country.

So, the dialogue mode of a TV-bridge over the mid-rate channel with a rate of 384 Kbit/s is provided with the use of two NAUKA stations conjugate to the equipment of compression TV studies, one of which is located at Brown University (Providence) and the second is placed at the Space Research Institute (Moscow), U.S.S.R. Academy of Sciences, during operations over the ninth trunk (TV) of the space segment. According to the preliminary estimate the cost of service should be essentially lower (by several times) than that of the traditional TV-bridge with the help of analog television. At present more than 10 TV conferences were performed as experiments

between Brown University and the Space Research Institute. Scientists in space physics, medicine, students, university students, and other specialists participated in these conferences.

We accepted the responsibility of demonstrating the system discussed above at this conference. For this purpose a TV-conference session through Brown University was planned to be carried out today. In this case Brown University should have played the role of relay station. Unfortunately, this experiment was not approved at this conference.

The next stage planned for implementation during 6 months of 1992 envisages the switch-on of one to three studios in the U.S.A. and the same number of studios in Russia. After this, it will be possible to use the systems for different tasks as well as for medicine, according to the conditions which will be adopted in the next week.

We suggest that the tariff for the system's use in the interest of medicine be reduced.

Thus, except for letters, telefax, fax, and telephone we will have a new means of telecommunication servicing video conferences. As to medicine, it could increase the efficiency of education, consultations, medical advice, prompt conferences in emergency situations, and so on.

An interactive video conference with the use of satellite channels is the novel technology that is most promising for many fields of science, medicine, engineering, and business.

The participants in the project I have the honor to present here, would be very pleased if on a top-priority basis representatives of medicine—and space medicine as well—one of the most humane sciences, could use the results of their effort.

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Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

Page 1 of 1

Page 2 of 2

Page 3 of 3

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**Use of Low Orbital Satellite Communications Systems
for Humanitarian Programs**

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Translated by L.R. Stone

INTRODUCTION

Communication and information exchange play a decisive role in progress and social development. However, in many parts of the world the communications infrastructure is inadequate and the capacity for on-line exchange of information may not exist. This is true of underdeveloped countries, remote and relatively inaccessible regions, sites of natural disasters, and of all cases where the resources needed to create complex communication systems are limited. The creation of an inexpensive space communications system to service such areas is therefore a high priority task.

In addition to a relatively low-cost space segment, an inexpensive space communications systems requires a large number of ground terminals, which must be relatively inexpensive, energy efficient (using power generated by storage batteries, or solar arrays, etc.), small in size, and must not require highly expert maintenance. The ground terminals must be portable, and readily deployable.

Communications satellites in geostationary orbit at altitudes of about 36,000 km are very expensive and require complex and expensive ground stations and launch vehicles. Given current technology, it is categorically impossible to develop inexpensive satellite systems with portable ground terminals using such satellites.

To solve the problem of developing an inexpensive satellite communications system that can operate with relatively small ground stations, including portable terminals, we propose to use a system with satellites in low Earth orbit, at an altitude of 900-1500 km. Because low orbital satellites are much closer to the Earth than geostationary ones and require vastly less energy expenditure by the satellite and ground terminals for transmission of messages, a system using them is relatively inexpensive. Such a system could use portable ground terminals no more complex than ordinary mobile police radios.

Between 1967 and 1989 the Scientific Production Association for Applied Mechanics and the Scientific Production Association for Precision Instruments gained experience in and developed technology for creating such satellite communications systems using COSMOS series low orbital satellites. This expertise and technology may be used to create inexpensive multisatellite communications systems.

CONCEPTUAL DESIGN OF THE SYSTEM

The inexpensive multisatellite communications system to be developed will utilize low-orbital satellites at altitudes of 900-1500 km. Information will be transmitted by the ground terminals to a satellite when it is in their coverage area, stored in memory, and then transmitted to its destination point (which may be located at any point on the globe) when the satellite flies over it. Thus the system operates according to the "electronic mail" principle.

A low orbital satellite may fly over a given point on the Earth's surface several times a day for a mean period of 8 minutes. Thus, if only a single satellite is utilized, a user needing to transmit or receive information would have to wait for on the order of several hours. Although such communication does not take place in real time, it nonetheless represents an enormous improvement in servicing of remote regions where delivery of message previously may have taken many days or even weeks. User service time may be significantly decreased by increasing the number of satellites in the system (system extension), while in the future relaying of messages between satellites will reduce the waiting period to close to real time.

It should be noted that within the coverage area of the satellite (diameter of the footprint is on the order of 5000 km) messages may be transmitted in real time.

Since low-orbital satellites are much closer to the Earth than geostationary satellites (by no less than a factor of 10), the ground terminals and satellites have less stringent energy requirements for transmitting messages (savings of no less than 20 db). This makes it possible to use small, portable, and inexpensive ground terminals, which may be powered by solar and storage batteries. For such a system, the following major design principles must be followed:

- Satellite and ground terminal antenna systems must be semidirectional.
- It is essential to use low frequency wave bands allotted to mobile communications, which improve the energy efficiency of the radio lines when semidirectional antenna are used.
- "Packet radiocommunications" technology, which minimizes the energy consumption of the satellite and ground terminals, should be used for communications.

- For efficient energy use by the satellite and ground terminals, modern signal level protocols should be used: phased (noncontinuous) methods for transmitting information, packet coding, and Weatherby decoding.
- The "electronic mail" message transmission mode is possible only if signals are completely demodulated on the satellite and stored for subsequent transmission to the user.

SERVICES PROVIDED

An inexpensive multisatellite communications system can transmit any data in digital form—telex, text, image, speech, exchange of information between databases or computers, and acquisition of data from environmental monitoring devices.

Messages may be transmitted in two modes. The "electronic mail" mode involves storage of messages in the satellite's memory and subsequent transmission to a user, when the sender and receiver are not in the satellite's coverage area at the same time. In the second mode the message is transmitted in real time. In this case the sender and receiver of a message must be in the satellite's coverage area simultaneously.

There are several possible variants of user ground terminals, depending on how they are to be utilized. In remote relatively inaccessible regions, where there are no means of ground communications, users will have direct access to the satellite through portable ground terminals in which information is input (and output) through a special device or personal computer. In regions where there are means of ground communications, access to satellite communications will take place through regional stations, which will "concentrate" the messages and organize their exchange between system users using ground communications lines and with the satellite using radio lines. Given this type of organization, many thousands of users from any point on Earth will be able to transmit short messages in a fixed format (portable ground terminal) or messages consisting of many pages of text in A4 format (stationary ground terminals or regional ground stations).

An inexpensive multisatellite communications systems would have the following areas of application:

- Communications on a global scale with users located in remote and relatively inaccessible regions with poorly developed communications infrastructure
- Transmission of emergency messages and coordination of rescue operations in areas affected by natural disaster
- Collection of ecological information from tended and nontended environmental status monitors on the ground
- Access to databases and communications lines of the "computer-computer" type

- Transmission of medical information
- Exchanges of business information for economic development.

In conclusion, it may be said that the creation of the "Gonets" system would be an important contribution made by the "Smolsat" association toward the development of a global community and the solution of problems in disaster medicine. The use of the technical expertise and capabilities of the Applied Mechanics and Precision Instruments Scientific Production Associations will make it possible to create the system at an accelerated rate with the least possible expense.

The major capabilities and technical specifications of the system and its components are described in the attachment to this report.

ATTACHMENT

"GONETS" MULTISATELLITE COMMUNICATIONS SYSTEM

Applied Mechanics Scientific Production Association

Precision Instrument Scientific Production Association

GOALS:

- Creation of an inexpensive space communications system
- Ground terminals must be portable, serviceable by nontechnical personnel, and inexpensive
- Rapid deployment of the system in emergencies
- Use of the system must be simple and inexpensive
- Support global communications, including polar regions, and a large number of users.

NOTE: Satellites in geostationary orbit (orbital altitude of 36,000 km) are very expensive and require expensive equipment for orbital injection, ground stations, and use. At present these satellites cannot form the basis for creation of an inexpensive satellite communications system with portable ground terminals.

BASIC PRINCIPLES:

- A system of low-orbital satellites will be used (orbital altitude of 1300 km-1500 km) (savings in energy compared to geostationary orbits of no less than 20 dB)
- Antenna systems of the satellite and ground terminals must be weakly directional (they will not be need to be pointed at each other)
- Frequency bands:
 1. 312-315 MHz (uplink), 387-390 MHz (downlink)
 2. 1642.5-1643.4 MHz (uplink), 1541.0-1541.9 MHz (downlink).
- Packet radiotechnology (minimizes energy consumption of the satellite and ground terminals)
- Advanced signal level protocols
- Phased methods of transmission, packet coding with Weatherby decoding (economy of energy consumption by the satellite and ground terminals)
- Complete processing (demodulation, decoding) of signals on the satellite and their storage for organization of the "electronic mail" mode of operation and energy savings.

SERVICES PROVIDED:

- Transmission of any data in digital form—telex, text, image, speech, exchanges of information between databases and computers, collection of data from environmental monitoring devices.

MODES:

- Electronic mail—with storage in the satellite's memory and subsequent transmission to the user (the sender and receiver not in the coverage area of a satellite at the same time)
- In real time (sender and receiver are in the coverage area of a single satellite at the same time).

MODERNIZATION:

- Introduction of intersatellite communications lines—enabling real-time transmission of information in all cases.

AREAS OF USE:

- Global communications with users located in areas with poorly developed communications infrastructure
- Transmission of emergency messages and coordination of work in areas of natural disasters
- Collection of ecological information
- Exchange of information between databases and communications of the "computer-computer" type
- Exchange of scientific and educational information
- Transmission of medical information
- Exchange of business information for economic development.

USER ACCESS:

- Direct access through a portable terminal equipped with an I/O device or personal computer
- Through ground communications lines, regional station (information concentrators).

SPACE SEGMENT:

Circular polar orbits (inclination 83°) altitude 1300 km - 1500 km

Six planes of six satellites each. The planes are separated from each other by 30° along the longitude of the ascending node

Group launch of six satellites at a time

Mean waiting time for a communications session no greater than 20 minutes, with probability 0.8

Orbital structure was selected under the assumption of homogeneous rate of traffic over the surface of the Earth (homogeneous servicing of the entire Earth), and minimization of the number of satellites. The orbital inclination was selected with consideration of existing launch trajectories.

NOTE: If traffic is no homogeneous over the surface of the Earth the orbital structure would be altered.

COMMUNICATIONS STRUCTURE

Marker signal for determining the presence of the satellite in the radiovisibility zone contains information for establishing communications: number of the satellite, nominal frequency, computation of temporal position for organization of scanning

Modes of operation: packet and data transmission.

Up- and downlinks will have three frequency channels each:

in the 300/400 MHz band:
data transmission channel 9.6 kbit/s
signaling channel—(4.8-9.6) kbit/s

in the 1.5-1.6 GHz band:
data transmission channel—64 kbit/s

Access protocol:
signaling channel—ALOHA
data transmission—as required.

Delivery of information: uncontrolled with addressing in the marker signals, information routed through the relay control center (up to 3 hours delivery time).

Number of users—up to 1,000,000

System capacity:
1.5/1.6 GHz - $2.5 \cdot 10^4$ Mbit/day or $2.5 \cdot 10^6$ pages in A4 format per day
300/400 MHz - $1.85 \cdot 10^3$ Mbit/day or $0.18 \cdot 10^6$ pages in A4 format per day.

SPACECRAFT:

Magnetic-gravity system of orientation (one axis) with accuracy of 5-10 degrees

Passive thermoregulation system with electric heater will provide a temperature of 0-40° C

Electric power system: solar arrays and nickel hydrogen storage battery—supports mean consumption per orbital pass of 45 W, 160 W per session

Communications antennas will be semidirectional with enhancement coefficient of 0-3 dB

Mass—225 kg

Group orbital injection of six spacecraft at a time.

RELAY:

Mass—60 kg

Rate of information transmission—4.8 kbit/s, 9.6 kbit/s, 64 kbit/sec

Capacity of on board memory—8 Mbytes (5000 pages in A4 format)

Working life—3-5 years, the spacecraft provides backup

Power of the transmitter—2-10 W

Noise temperature of the receiver—200° K

Mean energy consumption per orbital loop—45 W

Complete processing of signals, digital complex is programmable.

USER TERMINALS:

AT-M: Small, portable terminals:

Mass—1-3 kg

Power of the transmitter—2-5 W

Noise temperature—200° K

Station supplied with an IO device

Power - storage batteries

AT-S: Stationary terminals

Mass—60 kg

Transmitter power—5-10 W

Noise temperature—200° K

Personal computer

Power from storage battery and from an alternating current network.

REGIONAL STATIONS:

Mass—5- kg

Power of transmitter—50 W

Noise temperature—150°K

Personal computer

Device for linkage with ground data transmission lines

Power from alternating current network



Appendix A

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Final Project Report

**U.S.-U.S.S.R.
Telemedicine Consultation
Spacebridge to Armenia and Ufa**

Presented at the

**Third U.S.-U.S.S.R. Joint Working Group
on Space Biology and Medicine**

December 1-9, 1989

Moscow and Kislovodsk, U.S.S.R.



TABLE OF CONTENTS

<u>Item</u>		<u>Page</u>
1	Introduction	
2	Telemedicine: A Historical Perspective	1
3	Spacebridge to Armenia: Background	5
4	Communications and Network	9
5	Medical Consultations	12
6	Quality of the Consultations	25
7	Areas of Consultation	29
8	Consultation to Ufa	32
9	Results	41
10	Recommendations	42
11	Supporting Materials	45
		49

INTRODUCTION

A devastating earthquake occurred on December 7, 1988, in Soviet Armenia. This earthquake caused widespread destruction and loss of life and property. Help, both medical and material, was rushed to the affected area and many countries, including all the Soviet republics, cooperated together to provide initial help to the victims.

Two weeks after this tragic event, a concept of telemedicine consultation was developed by the National Aeronautics and Space Administration (NASA) and proposed to the Soviet Government under the auspices of the existing bilateral Space Agreement between the U.S. and U.S.S.R. Concerning the Exploration and Use of Outer Space for Peaceful Purposes, concluded April 15, 1987, and amended May 31, 1988. This proposal was made through the established U.S./U.S.S.R. Joint Working Group on Space Biology and Medicine, and implemented from May 4 through July 28, 1989. The Life Sciences Division, with the support of the Communications and Information Systems Division at NASA Headquarters, was responsible for the U.S. implementation phase of this project; and the NPO Soyuz Medinform and "Space for Health" organization were assigned the responsibility for the Soviet portion of this project.

The goal of this activity was to provide expert medical consultation to the Armenian medical personnel in the areas of plastic and reconstructive surgery, physical and psychological rehabilitation, public health and epidemiology.

The U.S. and U.S.S.R. implementation teams developed new standards for medical information transmittal as well as protocols and schedules on how to conduct medical consultations (See Supporting Materials). The consultations were provided to the Republic Diagnostic Center in Yerevan, U.S.S.R. by four U.S. medical centers: University of Utah/LDS Hospital, University of Texas, Maryland Institute for Emergency Medical Service Systems, and Uniformed Services University of the Health Sciences.

The idea for telemedicine consultations was simple in scope. However, many technical and logistic issues had to be worked out prior to its implementation. It was determined that the two most critical periods where such help is of utmost importance are immediately after the disaster or several months later. In the immediate time frame, telecommunications are important for the purposes of patient triage, planning

for long-term care, identification of medical supplies and expertise which might be required at the scene. In the follow-on time frame, telecommunications are primarily required for treatment of chronic problems and rebuilding of medical capabilities in otherwise devastated areas. Technical problems precluded the initiation of this project in the early phase. Some of the technical issues can be summarized as follows:

1. Identification and installation of suitable ground communications links
2. Identification and securing of suitable satellite channels
3. Conformance to the existing international communications policy and procedures
4. Training of participating personnel from different countries and suitable translations
5. Privacy of medical consultations.

In this instance, Intelsat and Comsat donated free access to uplink and satellite transponders and the Soviet Union donated the downlink channels. A ground station for video, voice and facsimile communication was rented from the "Stars" company in Houston, Texas, and deployed in the Republic Diagnostic Center. Ground communication lines were provided by NASA to the U.S. medical facilities, including the use of domestic satellites for retransmission of signals. All communications were encrypted in such a way as to protect the privacy of the patients. The U.S. team visited the Yerevan Republic Diagnostic Center and got acquainted with the facilities, layouts, and capabilities existing in Soviet Armenia. The Soviet team visited the U.S. medical facilities and the NASA Goddard Space Flight Center communication center, and familiarized themselves with the U.S. medical and communications experts, procedures, and capabilities. These preliminary exchanges significantly contributed to the later success of the Spacebridge. Precise protocols and procedures were developed prior to the initiation of the telemedicine consultation network, and were amended at a later time as necessary during the telemedicine sessions. A central communication status room was established at NASA Headquarters which played the role of a "dispatcher" and assured the smooth conduct of the sessions and resolution of "conflicts."

The unfortunate railroad accident happened on June 4, 1989, near the city of Ufa, during the existence of this network. Through the efforts of the Public Service Satellite Consortium (a private U.S. organization), the NPO Soyuz Medinform, and NASA

personnel involved in the telemedicine consultation Spacebridge, a satellite station consisting of a Slow Scan Video System, donated by Colorado Video, was deployed at the Ufa Medical Center and became operational 3 weeks later. This station was connected via ground links to the "Star" station in Yerevan and was serviced by both the U.S. and Armenian expert consultants.

Overall, the project was an outstanding success. Over 400 physicians and medical personnel from both countries participated in 51 sessions during the 3 months of existence of the Telemedicine Spacebridge. Experts consulted upon 253 cases representative of the general population affected by disaster. The communication links worked very effectively. In retrospect the language differences between the different medical institutions required working adjustments both from the patient and physician standpoint. Telemedicine has been tried on many different occasions over the last 20 years; however, never before was it deployed and tested on such a large scale.

This project demonstrated both the value of such a system and the need to institutionalize this capability nationally and internationally, so that it could be activated on demand. Today, elements of telemedicine exist on a regional or urban basis in the United States and are operating quite successfully. Telemedicine is also an integral part of the manned space program. It is important, however, that serious steps are taken today to plan for the development, maintenance, and associated training on a global scale system of telemedicine with appropriately dedicated communications, medical personnel, and even rapidly deployable, self-sufficient medical care systems. Areas stricken by serious disasters usually lack of all these components which are disrupted in the immediate post-catastrophe periods. To facilitate the dissemination of the experience gained as a result of this project, the U.S. and U.S.S.R. Joint Working Group on Space Biology and Medicine has formed a joint implementation team in telemedicine charged with the specific objectives of:

1. Supporting research to advance telemedicine support for space flight
2. Recommending application of the experience to space medicine and care of sick and injured space crews
3. Recommending applicability of currently available compact and self-sustaining medical care capabilities, such as the ones developed for Mir or International Space Station Freedom, to be included into the

telemedicine system for providing immediate care to victims of natural disasters

Arnauld E. Nicogossian, M.D.

TELEMEDICINE: A HISTORICAL PERSPECTIVE

The word **telemedicine** denotes the practice of medicine at a distance. The origin of this term is difficult to establish, and it has been probably coined as a result of the space age. What really constitutes telemedicine is a point of debate. In the early days of the telephone, telegraph, and radio, medical consultations were obtained between physicians by voice or mail. A critical step which preceded telemedicine was the need for and development of telemetry. Telemetry is a process for sending or receiving measurements, either physical or biological, from remote locations. Undoubtedly, the space age and the introduction of new means for communications, both audio and video, gave a new and expanding role to telemetry, biotelemetry, and later on to telemedicine. In the early 1960's and 1970's, the spinoffs from telemetry, or better biotelemetry, found their way into doctors' offices, hospitals, ambulances, and aviation. Gradually, links between different medical centers were established which serviced not only urban but also rural areas. Implantable devices such as pacemakers and defibrillators were developed which can telemeter the data via telephone and microwave links to physician offices and be individually programmed. Thus, the combination of electronic medical systems and communications, voice or video, became an efficient way of improving patient health care, and, in essence, brought the practice of medicine to the doorstep of where the patient resides. The combined system, referred to as telemedicine, has been effectively used to augment existing health care delivery systems, by providing a direct consultation link between remotely located medical personnel working with the patient and expert consultants at a central location.

The first experiment in telemedicine was conducted in 1971 with an NPSA-launched ATS-1 satellite. Experiments in the use of telemedicine in Alaska began under the auspices of the Indian Health Service (the arm of the U.S. Public Health Service responsible for providing health care to native Alaskans). Faced with the problem of servicing scattered small villages in remote regions and thwarted by the lack of reliable communication channels in the bush, the agency turned to telemedicine in the hope that consultation on a regular basis would improve village health services.

In one of the earliest health applications, 14 villages in the central Alaskan Tanana Service unit, 1 of 7 Alaskan health service units, were chosen to participate in a telemedical consultation experiment in conjunction with a service unit hospital in

Tanana. The experiment was financed by the Lister Hill Center for Biomedical Communication, and involved daily consultation between a local village health aide and a physician at the hospital.

In addition to teleconsultation, the system was used for communications between patients at the service unit hospital and their families in the villages. Because there was no telephone service to the villages, patients had been previously isolated from such interaction. The system was also used for interactive searching of MEDLINE, the National Library of Medicine online computer retrieval system in Bethesda, Maryland, and for transmission of a continuing education course on coronary care offered to nurses by the University of Alaska.

During the year 1974-1975, NASA's ATS-6 satellite added a video component to Alaska's telemedicine experiments.

The success of the ATS experiments is well documented. The number of contacts between doctors and health aides increased by 400 percent during the first year of the experiment. The State of Alaska and the Public Health Service subsequently transferred the health demonstrations to an operational system using commercial satellite services.

Similar medical assistance was given to appropriately equipped merchant ships at sea via the MARISAT system, which routes such requests for diagnostic help to a hospital on Long Island in New York City. In the same time frame, another project was being developed to apply the experience gained as a result of the Apollo/Skylab program to the 10,000 inhabitants scattered over 4,400-square-mile Papago region. A mix of electronic technology, closed circuit color television, and computerized patient data banks was developed for this purpose. Physicians at the Indian Health Service (IHS) Hospital near the center of the region consulted via television with community health medics (paramedics), who visited patients in remote villages on a regular basis in a large van called a Mobile Health Unit (MHU). Anywhere the MHU stopped in the vast region, it had instantaneous two-way contact with the IHS hospital. This project, which was very successful, was named Space Technology Applied to Rural Papago Health Care (STARPAHC).

One piece of equipment adapted for use in the Papago health care system is a suitcase-sized emergency treatment kit that allows communication between trained ambulance attendants at an accident scene and a physician at the IHS hospital. Originally developed for medical monitoring during the Skylab program, it is now marketed commercially. This portable kit is widely used by emergency medical systems throughout the United States to provide voice and telemetry communications of vital signs, electrocardiogram (EKG), and blood pressure from a remotely located patient to a central major medical center. It has permitted paramedical personnel to provide effective stabilization and care to cardiac and trauma patients, with significant improvements in their eventual outcome and survival as a result of improved early therapy. Also included in the kit carried in the ambulance are a battery-powered defibrillator and pacemaker, oxygen supply, aspirator, resuscitator and airways, laryngoscope, prepackaged drugs and supplies, and stethoscope.

A modified emergency system is now in use in Houston, San Antonio, and Corpus Christi, Texas; Montgomery County, Maryland; Altoona, Pennsylvania; San Francisco, California; and Cleveland, Ohio.

Although the original emergency package was widely used for adult medical transports, the system has been redesigned to transport high-risk, low-birth-rate infants from small community hospitals to a central Newborn Intensive Care Unit. Combined with appropriate thermal and respiratory support, this system was placed in use in 1978 and has transported nearly 500 infants a year in Northern California over distances ranging from 50 to 500 miles.

Reliable physiological monitoring and communications permit a largely dispersed population to benefit from a rather limited supply of highly trained personnel. This allows people in remote villages to receive better treatment and allows better control over the need for patient transport to a regional center when absolutely necessary for definitive care.

In 1985, another satellite developed by NASA, ATS-3, was used to help the victims of the devastating Mexico City earthquakes. Within 24 hours after the disaster, the satellite was on the air and was used extensively by the American Red Cross and the Pan American World Health Organization.

An additional example of telemedicine is the COSPAS/SARSAT communications satellite system, which became operational in the mid 1980's. U.S., Soviet, French, and Canadian satellites maintain a constant space-based watch for distress signals from marine, air, and land operations. Since their operations began, more than 1,000 lives have been saved. Currently, more than 15 nations participate in this activity.

Two other examples include ATS-6 which was positioned over India in 1976 for one year of health, education, agriculture, and cultural experiments; and the Communications Technology Satellite (CTS), a joint NASA/Canadian experimental satellite in the early 1970's (which was the precursor of today's broadcast satellites) used extensively for health care, emergency, and education applications.

NASA's commitment to serving the public continues today using its experimental resources in the United States, the Pacific basin, the Caribbean, and most recently, the Soviet Union.

SPACEBRIDGE TO ARMENIA: BACKGROUND

The earthquake which occurred in Armenia S.S.R. on December 7, 1988, caused over 150,000 casualties as well as widespread destruction. NASA, under the auspices of the U.S./U.S.S.R. Joint Working Group on Space Biology and Medicine, made an official offer on December 12th to the U.S.S.R. Government to provide humanitarian aid in the aftermath of the tragic disaster. The Soviet authorities accepted NASA's proposal for organizing consultative medical aid involving leading U.S. medical institutions and specialists via space telecommunications.

In March 1989, physicians from NASA and four U.S. medical centers as well as communication specialists visited Moscow and Armenia to organize a Spacebridge operation. Likewise, U.S.S.R. officials from the Ministry of Health, Ministry of Post, Telegraph, and Communication, Gostel Radio Agency, and the Republic Diagnostic Center (Yerevan, Armenia) visited the U.S. in early April to finalize the arrangements. As a result of these exchanges, a Protocol and Implementation Plan (See Supporting Materials) were signed by NASA and U.S.S.R. officials agreeing to the Spacebridge which would enable Soviet physicians at the Republic Diagnostic Center in Yerevan to consult via audiovisual network with American medical specialists in four centers.

It was anticipated that Spacebridge would be in operation from May 3rd until the end of June. However, due to another tragedy, the Ufa train accident of June 4th, in which there were over 1,200 casualties, the U.S. immediately offered to extend the Spacebridge for an additional month in order to provide further consultation for these casualties. The Soviet Government immediately accepted the offer thereby permitting Spacebridge to continue until July 28th.

Once communication equipment, which was transported by Aeroflot from the U.S. to Yerevan, was installed and operational, broadcasts were able to commence on May 4th. They continued accordingly until the final day of operations on July 28th, when Spacebridge was officially terminated.

Interest in the use of telecommunications for medical purposes has grown steadily in recent years. Various nations have gained significant experience with transmitting medical information by means of digital, acoustic, facsimile and video equipment along appropriate communication channels. Modern telemedicine has taken the

following major forms: medical support of space station crews and other isolated groups; creation or improvement of access to literature in medical libraries; production of single, series and ongoing programs for educational objectives; organization of interactive medical conferences in the form of seminars, scientific discussions, and consultations; solution of administrative and practical problems associated with medical relief measures directed at elimination of the consequences of natural disasters and catastrophes.

Due to NASA's unique expertise in the application of the most advanced satellite technology to problems in public health, and to the readiness of medical personnel of four major U.S. medical centers to share their knowledge and experience, the medical personnel of the affected areas of Armenia had the opportunity to consult with American physicians on issues in a number of medical specialties. Leading specialists from the Uniformed Services University of the Health Sciences (Bethesda, Maryland); the University of Maryland Institute of Emergency Medical Services Systems (Baltimore, Maryland); the University of Texas Health Science Center (Houston, Texas); and the Latter Day Saints Hospital and University of Utah (Salt Lake City, Utah) acted as consultants for Armenian physicians for 3 months.

Medical interaction and coordination of work in the U.S.S.R. was organized by the "Soyuzmedinform" Scientific Production Agency of the U.S.S.R. Ministry of Health, which is the lead organization for the "Space For Health" program. The general director of this organization, Professor A.A. Kiselev, acted as project director for the Soviet side. The "Diagnostika" Scientific Production Organization of the Armenian S.S.R. Ministry of Health was selected as the base organization for the preparation and conduct of the teleconferences. The director of this organization, H. Nicogossian, acted as medical coordinator of the project in Armenia.

After the train crash in the Bashkir Autonomous S.S.R. in June 1989, it was decided to establish a temporary teleconferencing studio in the city of Ufa, where numerous burn cases were being treated, and to connect this studio to the Yerevan-U.S. teleconferencing network, which had already been operating for 2 months.

Thus, the "Armenia-U.S.A." medical telebridge with the "Ufa-Armenia-U.S.A." hook-up became the first example in history of the use of a system of satellite communications

in support of systematic, long-term, multidisciplinary collaboration among the medical personnel of two nations.

COMMUNICATIONS AND NETWORK

The NASA Communications Division of the Goddard Space Flight Center (GSFC), which has NASA-wide responsibility for design, implementation, operations and maintenance of the operational communications network, the Nascom Network, was given the assignment to meet the communications requirements of the Medical Spacebridge.

The communications links supporting the Medical Spacebridge between various U.S. medical centers and Yerevan, Armenia was accomplished utilizing a combination of domestic and international satellite and terrestrial networks, communications facilities and services.

The major components of the service were: a transportable C-band earth station; two INTELSAT C-band transponders; two earth stations at Roaring Creek Pa. - one for international service and one for domestic service; an AT&T domestic satellite transponder; and AT&T terrestrial private voice lines.

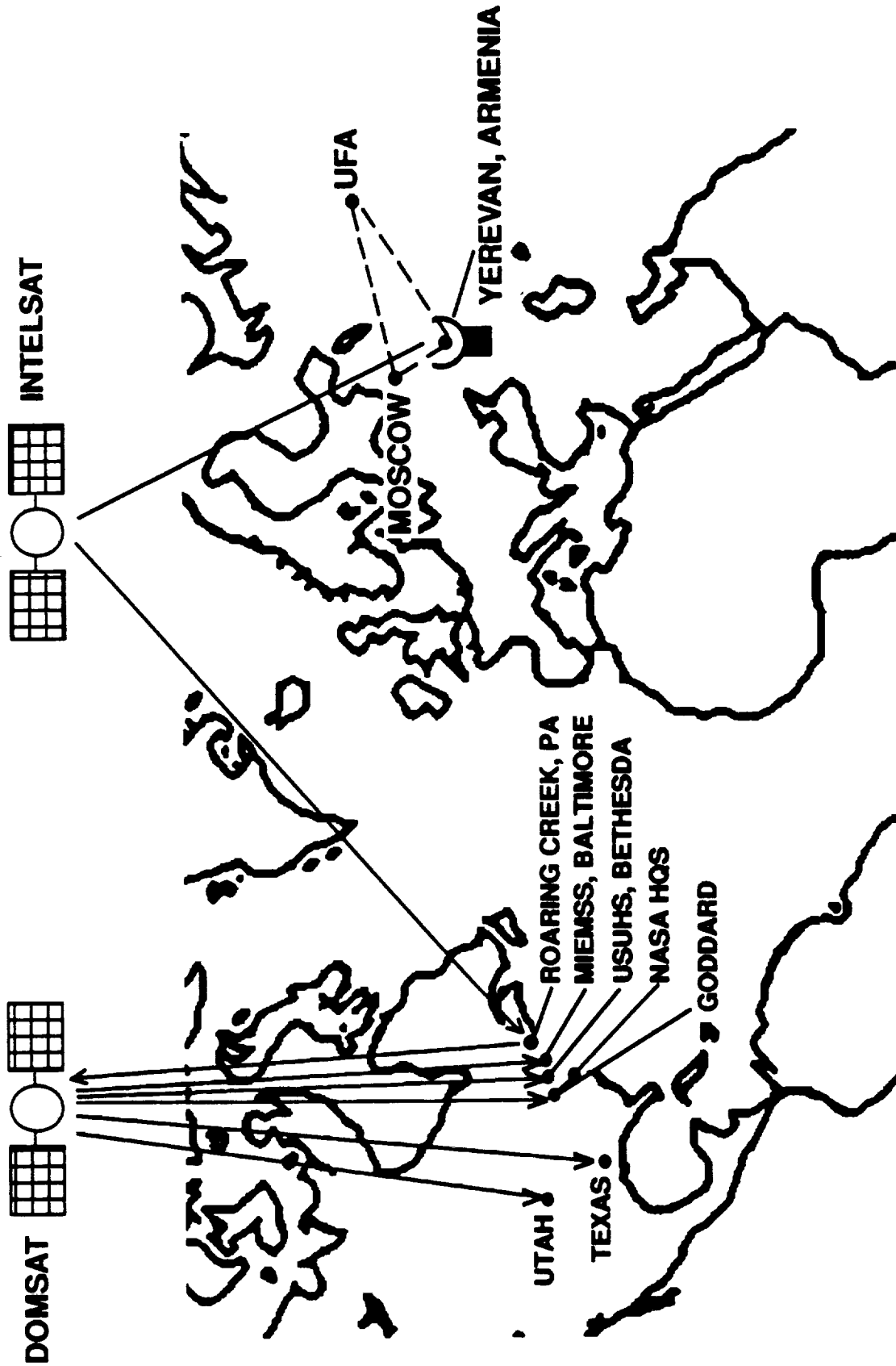
To accomplish the end-to-end service required coordination and cooperation of several different organizations. Primary organizations were: Satellite Transmission and Reception Specialists (STARS) of Houston, TX; the International Telecommunications Satellite Organization (INTELSAT); the Communications Satellite Corporation, (COMSAT); and the American Telephone & Telegraph Company (AT&T).

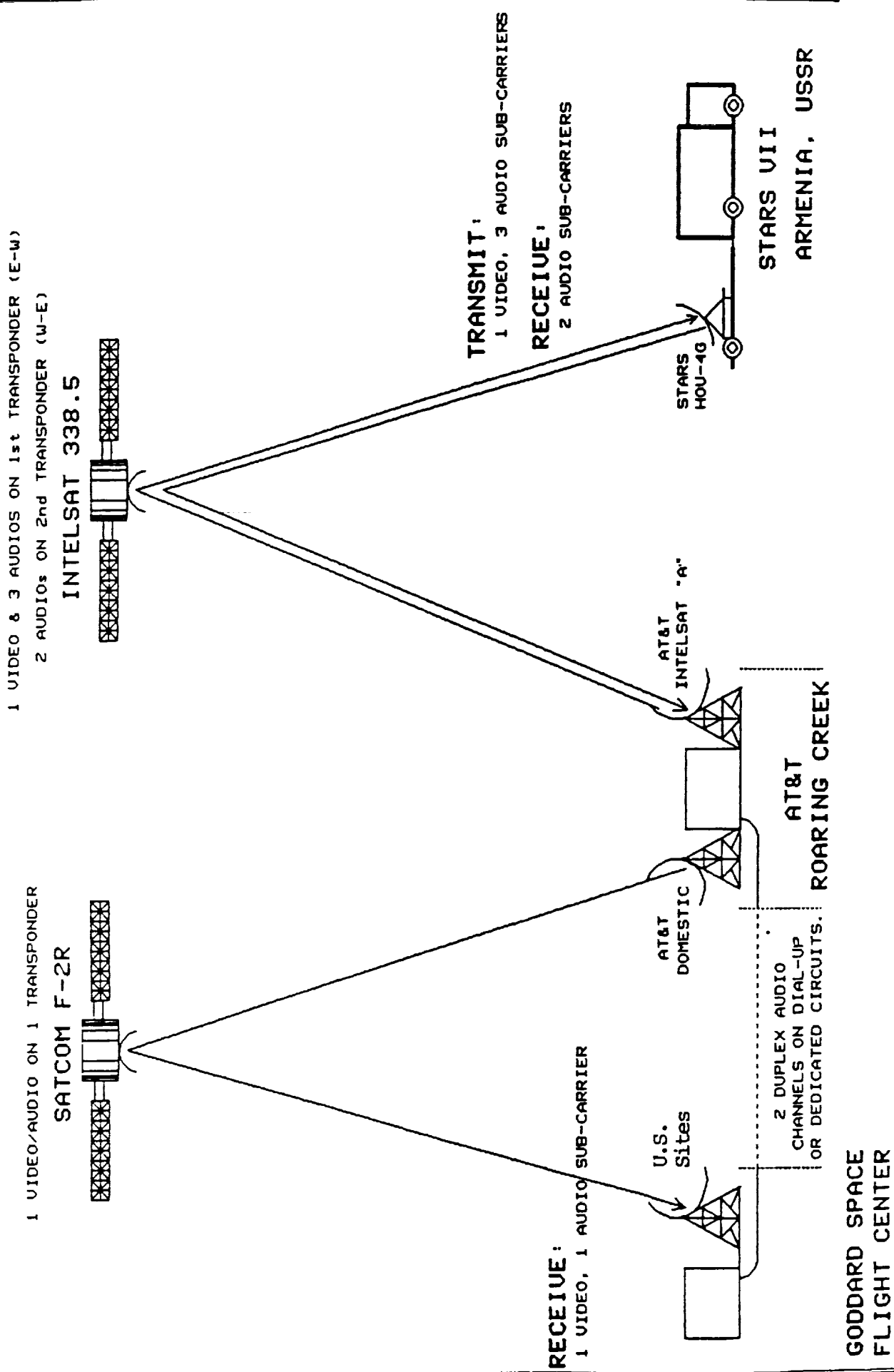
The U.S.S.R. Ministry of Post, Telegraph, and Communications and Gostel Radio Agency ensured that the frequencies utilized were available and free of interference. Furthermore, they provided free of charge down link capability and arranged communication links between Moscow and Yerevan.

STARS was the primary communications carrier involved in this service which consisted of a one way video channel from Yerevan to the U.S. and two duplex voice grade channels, one intended for the medical conference and one for communications coordination. Either voice grade channel could be used to support the Medical Spacebridge, but not simultaneously. The voice terminating equipment was equipped with a switch which would allow use either in the voice or facsimile mode. STARS

TELEMEDICINE SPACEBRIDGE

COMMUNICATIONS NETWORK





provided a transportable Earth Station and technicians in Yerevan. These technicians also assisted in the initial installation and training of hospital personnel in Yerevan in the use of the video, voice and facsimile equipment, in addition to the operations and maintenance of their facility. STARS was also the responsible party for obtaining all authorizations for the use of the INTELSAT transponders. On the international portion of this service, two transponders were used, one transponder was used for the video of and the accompanying audio channel while the other transponder was used for the two voice channels.

STARS also obtained the use of an AT&T earth station at Roaring Creek, PA to be used in conjunction with the STARS Yerevan earth station. Distribution of the Yerevan signal to the U.S. medical locations was planned to use a NASA obtained transponder on GE American Communications, Inc. domestic satellite, F2R. When the AT&T transmission from Roaring Creek to F2R caused interference to an adjacent satellite service, AT&T made available to STARS (and the Medical Spacebridge) a transponder on an AT&T COMSTAR satellite. The video signal with audio was downlinked to the U.S. medical locations. STARS was also responsible for the acquisition and installation of the receive only antenna and associated equipment at several locations. This arrangement provided near broadcast quality, (limited in quality by the camera's used) full motion video for the four hours, five days per week for approximately three months. At the request of the Soviet Union, the signal was also scrambled for the U.S. domestic broadcast, the scramblers and descramblers were provided by STARS.

From Roaring Creek, two private line voice grade services were installed to the Goddard Space Flight Center (GSFC). One service terminated there and was used as a coordination channel. The other was interconnected to a multipoint private line with terminations at all of the U.S. medical centers and NASA Headquarters. Simultaneous transmission of facsimile and voice could not be accomplished.

Along with the video equipment, cameras, monitors and VCRs, NASA provided the voice terminating equipment and the facsimile machine.

Daily coordination and monitoring of the Bridge was accomplished by the Bendix Field Engineering Corporation who has the operations and maintenance responsibilities for the Nascom Network.

The Soviet Government accepted additional communications links as a result of the Ufa gas explosion. NASA extended the Spacebridge to include black and white slow scan video and voice communications between Ufa and Yerevan for retransmission through the Spacebridge to the United States. This equipment was used because of the need to quickly establish simple to operate links using existing Soviet terrestrial voice circuits and infrastructure not capable of accommodating full motion video. It permitted adequate quality photo images of the burn victims, taken by Soviet physicians, to be transmitted every 20-40 seconds as well as audio teleconferencing.

This quick response was made possible by an intensive coordinated effort by the Soviet Ministry of Health and the Ministry of Post and Telecommunications. The slow scan video transceivers were donated by Colorado Video of Boulder, Colorado at the request of the Public Service Satellite Consortium (PSSC). PSSC provided telecommunications consultation in support of NASA and the USSR Ministry of Health.

The Soviet Union provided transportation of the STARS terminal, NASA provided equipment, and the STARS technicians to and from Yerevan as well as food and loading for the technicians while in Yerevan.

From a NASA Communications Network point of view the service quality was very good and most of the daily programming was accomplished with few impacts caused by communications problems.

Voice Communications

The major mode of communications used by the participants in the telebridge was voice communications. The high quality of the acoustics served to prevent difficulties in speech intelligibility.

Initially it was planned to use a single microphone to "cover" the entire conference room, with a second microphone available to the interpreter. However, it soon became necessary to eliminate the background microphone, since it was a source of interference when a large number of participants was present. In the second arrangement, two microphones with lower amplification were made available to teleconference participants, and a third was given to the interpreter. The microphones of the physicians, who spoke Armenian and Russian, served a purely psychological

support; the physicians felt more at ease when a microphone transmitted their words, even though what they said was not comprehensible to the listeners. Of course, hearing the intonations and emotional overtones of the speaker's voice was also useful, creating a situation that was closer to normal human communication.

The second microphone, which was left on in the majority of cases, was a continuing source of interference, since the person holding it and the people in his vicinity frequently forgot that their voices, along with that of the speaker, were being picked up. For this reason, for the final version it was decided to have only two microphones in the hall, one for the participants and the second for the interpreter.

A second acoustic channel, used mainly by the conference coordinator, was also important. First, it provided a link with the Goddard Flight Control Center, which constantly monitored communications and maintained the telebridge configuration; second, it was the "back-up" channel in case of interference or malfunction of the primary television acoustic channel.

Virtually the sole problem associated with voice communications was the frequent occurrence of feedback or echo (or, in the parlance of Soviet communications specialists, "snarl"). The source of this echo was a "hot" (switched on) microphone near the speaker. The transmitted voice was picked up by the microphone and transmitted with a delay along the voice channel, amplified for each transmission-reception cycle. The phenomenon occurred with variable frequency during many conferences, at times seriously disrupting the proceedings. The "echo" was more likely to occur when there were more medical centers participating in the conference. One means for eliminating this phenomenon would have been a push-button switch for the microphones ensuring that they were only on while pressure was maintained on the button.

Video Communications

The Armenia-U.S. video channel made it possible to hold full medical teleconsultations. As the project was being planned and developed, it was thought that it might be necessary to include a special digitizing device for transmitting x-rays and other medical images along the acoustic channels in the telebridge configuration, as it was feared that the quality of the images transmitted along the video channel would not be sufficiently high. However, this fear turned out to have been unjustified: the telebridge video channel satisfied all requirements.

The video channel served three major functions in the teleconferences:

1. *Visual access to the patient.* The attending physician conducted a physical examination which was observed by the consulting specialists. Throughout the period that the telebridge was operational there was not a single instance where the quality of the transmitted image was considered unsatisfactory. The color of the patient's skin, the condition of his mucous membranes, wounds, scars, and other changes observed during the examination were clearly visible in the U.S. medical centers. The high quality of the video transmission of movement is especially worthy of note. Observation of patient limb movements and gait is often critical to the evaluation of orthopedic cases. In neurological pathologies it was necessary to demonstrate tendon and other reflexes, disruption of motor coordination, etc. In consultations on patients with psychiatric problems, much attention was devoted to body language, facial expression, and appropriateness and other properties of movement. In addition, the video channel was used to transmit video records of such dynamic diagnostic procedures as fluoroscopy, endoscopy, ultrasound, and other diagnostic and therapeutic manipulations, as demonstrated in a video transmission from the University of Utah on June 28.
2. *Video presentation of medical images, curves, diagrams, charts, etc.* The transmission of medical images constituted a significant portion of the video transmissions for the telebridge. Many of these were images on a transparent x-ray film: x-rays, angiograms, computer tomography. These images were shown on a light box so that ambient illumination did

not have to be turned off. Images on nontransparent media (paper) — sonograms, curves, photographs, etc. — were visible under conditions of normal illumination. The majority of images were depicted in shades of grey — ranging from white to black. During the trial video-communication session, "grey scale" test images typically used for the adjustment of medical monitoring apparatus were transmitted. The receiving centers confirmed that all the gradations of grey on the test pattern could be distinguished. Thus, in combination with adequate accuracy (good resolution) and the good brightness-resolving capacity when the monitors were properly adjusted made it possible for the x-rays and other medical images to be transmitted virtually without loss of information. Some participants expressed the opinion that in many cases the transmitted image was superior to the original, due to the presence of a "zoom lens" that made it possible to magnify portions of the image, and also to automate brightness regulation. Thus, in the unanimous opinion of the Armenian participants in the Armenia-U.S. telebridge, there was no need for special equipment to transmit x-rays and other medical images. This was demonstrated by the level of detail with which the images were interpreted by the consulting specialists.

3. *To show the audience.* In the intervals between showing the patients and diagnostic images, the camera was directed at the physicians participating in the conference. It would be redundant to again emphasize the psychological value of this procedure above and beyond the medical information transmitted.

When the patient could not be present in the conference hall because of the severity of his condition, danger to others, medical contraindications, or great distance, visual observation of the patient was enabled by transmission of a video tape of a previous examination in the hospital ward. During the period the telebridge was in operation, consultations on more than 15 patients were conducted in this way. Such conferences included those focusing on infections in children, and were resorted to in the majority of the conferences on spinal pathology and neurosurgery. The playing of the video tape was accompanied by commentary from the conference hall. After the tape had been played, x-rays and other medical images were shown.

Aside from showing the patient himself, this use of the video channel made it possible to display the conditions under which the patients were being treated and to create the impression that the consulting physicians were present at and participating in the examination and treatment of the patients. The preliminary preparation of the videotape offered an important advantage in that it could be done without rushing, in the less frenetic environment of the hospital ward. The major shortcomings of this technique were that it precluded direct contact (conversation) between the consulting physicians and the patient, and precluded video transmission of additional symptoms not photographed when the film was prepared.

In the Ufa component of the telebridge, the output signal of the slow-scan transceiver was transmitted along the video channel. When the system (Colorado Video, model 250) was used, each static black-and-white image required 80 seconds to be transmitted along an ordinary narrow band telephone channel between the cities of Ufa and Yerevan. However, since discussion during the conference required a great deal of time, such slow transmission of the images did not disrupt the normal course of the conference. No complaints were made about the quality of the images. The only palpable shortcoming of the slow-scan video was the absence of color and movement. Sometimes there were differences of opinion among the participants concerning the suitability of slow-scan video for telemedical consultation. Professor John Siegel (Shock and Trauma Center, Baltimore), for example, expressed the opinion that the absence of color in the images could increase the chance of physician error. For consultation on burn patients, on the other hand, the consultants in Texas and Utah pronounced the slow-scan video "completely satisfactory." Overall, slow-scan video was deemed suitable for consultations on the majority of pathological conditions, and completely adequate for transmission of x-rays and other black-and-white medical images. Moreover, when x-rays are transmitted this technique permits preliminary processing to enhance essential details, which is an advantage of slow-scan video over ordinary television for transmitting x-rays.

The majority of participants in the telebridge regretted the absence of two-way video communications. This question must be posed as follows: do the advantages of two-way video justify the required expenditure of time and resources? A 2-hour experiment with the physicians at Utah showed that the advantages of transmitting video signals from the consulting centers to Armenia include extensive opportunities for teaching, the possibility for illustrating what the consultants are saying, and the

major positive psychological effect on the participating patients and physicians. Thus the answer to the question depends on the purpose and type of teleconference. In the "Armenia-U.S." telebridge, in which the conferences mainly involved teleconsultation, two-way video would be desirable, but would be unlikely to yield significantly new or major results.

Facsimile Communications

Facsimile communications, along with voice and video communications, were an enormous factor in the success of the "Armenia-U.S." telebridge. The facsimile communication line was used to transmit the following information from Armenia to the consulting centers:

- Medical data prepared according to an agreed format for the patient consultations
- Lists of participants in the conferences
- Lists of specific questions of the Armenian physicians
- Lists of literature requested by the Armenian physicians
- Corrected agendas for upcoming conferences
- Miscellaneous communications, requests, etc.

The following information was sent from the U.S. consulting centers to Armenia:

- Written consulting recommendations
- Literature on past or upcoming conferences
- Written answers to questions
- Lists of participants in the conferences

- Miscellaneous communications, etc.

Although the quality of the photographs, x-rays, etc. in the literature was considerably degraded in transmission, the overwhelming majority of the materials remained intelligible and useful. More than 1000 pages of medical information were transmitted while the telebridge was functioning.

Unfortunately, for technical reasons, facsimiles could not be transmitted during the conferences, so special communication sessions were devoted to facsimile transmission. During these sessions, all the technical personnel and communications apparatus were devoted to the facsimiles. Aside from saving time and resources, simultaneous facsimile transmission could have facilitated more efficient exchange of information during the conference.

In addition, since most of the information originating from Armenia was transmitted to more than one participant, the capability for transmission to two or more recipients would have been desirable. Another relative disadvantage of facsimile communication was the uneven rate of transmission. In most cases, transmission from Armenia to the U.S. proceeded at a rate of 9600 baud, while transmission in the other direction was almost always twice as slow, at 4800 baud. Nevertheless, both the quality and the content of the facsimile material received satisfied the majority of telebridge participants.

It is difficult to draw conclusions of the relative importance of one or another mode of communication in the functioning of the telebridge. To illustrate the utilization of all three modes of communication for consultations on a specific patient, we may cite one of the most interesting consultations, both from a medical and an technical point of view. This consultation involved a 9-year-old girl with cerebral paralysis and subluxation of both coxofemoral joints. Because of the unavailability of the appropriate consultant, the entire video presentation of the patient was recorded on video tape with detailed commentary. Detailed medical data were sent via the facsimile channel. A video cassette was then sent to a specialist in this specific area, who after studying all the data used a new technology of computer analysis of x-rays to plan orthopedic intervention. Along with the minutes of the consultation and the sources in the literature, a blueprint for the operation printed by the computer program for planning orthopedic operations was sent on the facsimile channel. In this example,

all three forms of communication were necessary to maximize the value of the consultation.

MEDICAL CONSULTATIONS

Communication equipment was installed in Yerevan in late April and early May with the first broadcast to the U.S. on May 4th. A patient with complicated pancreatitis was presented along with x rays in order to fully test the system. All the physicians felt that color television and voice transmissions were of excellent quality — furthermore, the transmission of x rays, CT, and ultrasound was surprisingly good. Translation (Armenian, Russian, English) was ably performed by one physician and an assistant in Yerevan. With this very successful opening broadcast, all of the participants enthusiastically anticipated the first earthquake casualty consultations.

As part of the Implementation Plan, a daily calendar for May and June was included which contained the subject matter to be discussed each day (See Supporting Materials). Furthermore, that U.S. medical center which had the most expertise was appointed lead for that day, although the remaining three centers were always invited to join in at any time. Usually two or three centers were on the air every day, each one contributing to the discussion regardless of who was designated the lead. In general, the scheduled consultations took place as indicated on the calendar, although at times some days had to be interchanged or modified because of unforeseen events or the unavoidable absence of clinicians or patients. Teleconference topics were selected on the basis of the specific needs of the Armenian physicians.

As the schedule went, there were broadcasts Monday through Friday (excluding U.S. and Soviet holidays), 9:00 a.m. - 1:00 p.m. EDT (6:00 p.m. - 10:00 p.m. Armenian time). Every Friday, Armenia would fax to the U.S. medical centers information on patients to be presented the following week. This then allowed the centers to prepare in advance for the discussion and to ensure the presence of the appropriate specialists. On the following Monday, the U.S. medical centers would then fax to Armenia journal articles and papers relative to the cases to be presented that week. On Tuesdays, Wednesdays, and Thursdays, the Armenian physicians would then present those cases for which they desired consultation. Frequently the patient was present and was examined in front of the camera; x ray, CT, and ultrasound studies were usually available as well. A lively exchange would then ensue, with particular emphasis upon management.

Communications sessions on Monday and Fridays, unfortunately, were clearly not efficient. For example, after communications had been established, it sometimes happened that the participants had not planned any transmission for that day or that the planned facsimile transmissions for that day would require only 1-2 hours. Therefore, on these days, the use of communications time was inefficient. It would have been possible to coordinate the transmissions needed for facsimiles and associated time requirements in advance, and use the remaining time more efficiently, for example, for short conferences on a very specialized area with a limited number of participants.

Subsequently, experience showed that if the number of conferences in a block exceeded four, it was expedient to divide the block into two sessions, separated by an interval of 1-2 weeks. Aside from psychological relief, this allowed time for the formation of interim conclusions from the results obtained, study of the literature that had been sent, and better planning of further telebridge activities on the particular topic.

In accordance with the mutual agreement of all participants in the conferences and organizations supporting communications, and taking account of the time difference of from 9 to 11 time zones, the conferences were held between 6:00 and 10:00 p.m. Yerevan time, which corresponded to 7:00 - 11:00 a.m. in Utah, 8:00 a.m. - 12:00 noon in Texas, and 9:00 a.m. to 1:00 p.m. in Maryland. Four hours were allocated to each conference. The Armenian physicians attended the conferences after their work day, while their American colleagues sacrificed work time. This was the sole mutually agreeable time interval.

The Armenian physicians disagreed about the duration of the conferences. Without doubt, 4 hours of high intensity work represented a significant mental strain for all the participants, especially the Armenian physicians. However, the great interest and practical benefit of the conferences prevented even a single participant from complaining of fatigue. A 10- to 15-minute break during the conference was a necessity, since by the end of the first 2 hours, the physicians sorely needed a short rest.

Ongoing planning and support of the functioning of the telebridge required major organizational efforts on the part of all participating organizations. The central

coordinating link in the telebridge structure was, without a doubt, the NASA Life Sciences Division. The medical coordinator on the American side, Dr. Russell Rayman, participated in all conferences, addressing on the spot any problems that arose. His colleague from Armenia, the director of the "Diagnostika" Scientific Productive Organization, Dr. Haik Nicogossian, was also always available.

The conference leader on the Armenian side, Dr. Ashot Sarkisian, also participated in all conferences. Since the majority of participants on the Soviet side were participating in teleconferences for the first time, substantial time was devoted to working out a format for presenting data and sequencing the various types of activity. The leader had to receive information on upcoming conferences ahead of time and arrange for its translation. His responsibilities included establishing communication, coordinating the conference agenda, and other administrative matters.

Groups were formed to consider each topic. Each group was composed of leading specialists who prepared the patients for the presentation and compiled documentation, lists of questions, and requests for literature. Two employees who knew English worked on alternate shifts in the studio: setting up the communications and notifying the appropriate individuals, copying and distributing material, preparing data for facsimile transmission, and filing.

A very positive factor was the powerful diagnostic capability of the institution in which the teleconference was organized and conducted. No fewer than half of the patients presented for consultation, some directly before or after it, were given additional examination in the "Diagnostika" organization.

The standard mode of presentation of patients' medical data, which had been agreed upon ahead of time, proved satisfactory. It was utilized in all cases when the working groups presented their data on time.

In cases where written information about the patient was sent in advance, repetition of the same information during the consultation was superfluous. Such time could have been used more efficiently for discussion of details, presentation of additional x rays, etc.

Quality of interpretation was one of the most important factors in the bilingual conferences of the "Armenia-U.S" telebridge. In the unanimous opinion of all

participants, the interpreter Valentina Simonenko was all that could have been desired. However, the following conclusions can be drawn. First, in a number of pathological states, translation into the patient's language plays a key role; for example, consultation on patients with psychological disturbances. Second, significant time can be gained by including a physician who knows both languages. Without being a professional interpreter, the physician is nonetheless capable of ensuring mutual understanding through short and accurate translation of the meaning of what has been said and through his knowledge of the basic terminology, Latin terms, equivalent terms for drugs, normal values of laboratory data, and a full understanding of what is being translated. Experience with the conferences showed that such a physician could significantly reduce the time required for interpretation. In conversation among colleagues, it was often possible to replace a long sentence with only a few words. The professional level of the interpreter Simonenko would have permitted simultaneous interpretation. However, the absence of the appropriate technical conditions and devices required interpretation that was primarily sequential. Of the two alternatives — sequential interpretation by a physician and simultaneous interpretation by a language specialist — the latter is definitely preferable.

The quality of the translation of texts transmitted to the consulting centers was also important. Lists of the questions discussed, lists of participants, and final patient data were sent via the facsimile channel after translation into English.

QUALITY OF THE CONSULTATIONS

Overall, the Spacebridge project, in spite of its complexities, was considered a great success by all parties. The telecommunications system performed magnificently, providing excellent audiovisual quality. Furthermore, the quality of transmission of x rays, CT, and ultrasound went well beyond what was expected by the physicians. The overall success of the communications network is attested to by the fact that only 2 of 55 broadcasting days had to be cancelled due to technical malfunction.

Discussion of how well the teleconferences were organized may begin with the words of one of the most active participants in the telebridge — Dr. Bruce Houtchens, a professor at the University of Texas: "When the right people are present, the right things get done." For the right people to be present at the conferences, it is essential to:

- Follow the schedule to the maximal extent; changes in the schedule must only be made well in advance.
- Send data on the subjects of the consultation no later than 3 days ahead of time.
- Prepare and send lists of very specialized questions well ahead of time, to allow time to invite the necessary consultants and prepare appropriate answers and material.

Of course, these requirements cannot always be met in every instance. Urgent consultations not stipulated in the plan naturally may force exceptions. However, in planned medical teleconsultations on the "Armenia-U.S.A" telebridge, such cases should occur only 10 percent of the time, while in actuality they constituted 50 percent of all the consultations.

It is very important that each teleconference be well organized. The conferences proved most useful, interesting, and substantive when they were carefully prepared ahead of time, and structured to constantly retain the interest of the participants. The most interesting conferences were those in which:

- Patients were actually presented. Experienced practitioners eagerly discussed differential diagnoses, examined x rays, and sought confirmation of their hypotheses, consulting with each other. When the patient was present in the hall, he was virtually always asked additional questions. Many questions were asked of the attending physicians.
- Discussion of pathogenesis, therapeutic or diagnostic methods followed specific consultations or, in other words, the patients were selected in accordance with the issues discussed.
- There were few or no long speeches or analyses by individual participants that went beyond the limits of the specific issues discussed.
- Specific questions were asked that required specific answers.
- The format of presentation of the patients was appropriate; information about the patient was objective and unbiased
- Information about the patients was sufficient.

Sufficiency of the information provided played a direct role in determining the efficacy and completeness of the consultation. The reluctance of consultants to base their conclusions on insufficient information, and to replace conclusions by guesses, must be understood. An example might be the nephrological patient whose diagnosis was unclear and for whom kidney biopsy data was lacking. The availability of these data would have diminished the likelihood of differential diagnoses, and the consultant would have been more confident that the treatment he recommended was appropriate. Unfortunately, in a number of cases the attending physician did not bring all the x-rays, encephalograms, etc., to the conference. The reluctance of participating consultants to blindly accept oral descriptions was understandable.

It is essential to note the psychological strain on the consulting specialists. During the consultations they had not only to express their opinions, but to justify them, and even convince the other participants of their correctness.

A great deal of attention was given to deontological issues during the functioning of the "Armenia-U.S." telebridge. On U.S. territory, the video signal was propagated in a coded form, in order to guarantee the medical privacy of the patient and avoid accidental reception by private individuals or nonmedical organizations.

The period in which the patient was presented and the period during which his case was discussed were strictly separated in the overwhelming majority of cases. That is, after the patient was examined and questions put to him, he was asked to wait in an adjoining room, with the understanding that he might again be asked to come to the hall during or after the consultation.

The physicians were not the only participants who were disappointed with the absence of video transmission from the consulting centers. The patients were even more disappointed that they could not see the consulting physician, in whom they had placed such great hopes. The opportunity to see the physicians undoubtedly would have had a positive psychological effect.

AREAS OF CONSULTATION

While the "Armenia-U.S." telebridge was in operation there were 31 thematic conferences (i.e., conference devoted to a single topic), in which 230 physicians participated on the Armenian side and 405 on the American side. During approximately 124 hours of work, consultations were held for more than 200 patients, about 30 of whom were present at the conferences. (Cf. Table 1). As the table shows, the conferences covered more than 13 medical specialties.

Of the 230 physicians participating in the conferences, more than 60 were lecturers at the Yerevan Medical Institute and Yerevan Institute of Advanced Physician Training, including more than 20 who regularly lecture to specialists, 50 directors of medical institutions, 10 chief specialists and directors of branches of the Armenian Ministry of Health, and 9 foreign physicians.

The medical results of the teleconferences were deemed significant by all groups of specialists. These results can conveniently be categorized according to the major focus of the the physicians during the conferences (Cf. Table 2).

As the tables show, the medical results go far beyond consultative aid for individual patients. Unlike the majority of past experiments, here the patients were introduced by their own physicians, who frequently were specialists in their area. It should be noted that in approximately 25% (53 of 210) patients, the diagnosis was changed after consulting with the U.S. specialists.

The following discussion of the medical results of the conference is organized according to conference topic.

Surgical Conferences

A leading role in teleconsultations on surgical patients was played by visual information — pictures of the locus of injury, gait and other physical signs, and also a large number of x rays, tomograms, etc. This was equally true for orthopedic, spinal, and neurosurgical cases. Laboratory data and the results of general physical examinations played a much more minor role in these cases. Surgical

Topic	# Confs	Total Hours	Table 1 # Physi- cians	# Consul- tations	Pages Facs	Group Eval.
Surgical group	5	20	38	44	232	
Psychology	7	28	24	25	451	
Epid/Infec.	4	16	42	5	69	
Int.Disease	1	4	13	5	--	
Diagnostic visualization	2	8	33	33	79	
Laboratory med	1	4	14	--	77	
Burns/Ufa	5	20	14	24	20	
Vascular surgery	1	4	5	16	25	
Endocrino- logy	1	4	11	5	--	
Ophthal- mology	1	4	25	6	51	
Neurology	1	4	8	4	--	
Urology	1	4	3	25	--	
Dialysis	1	4	17	6	30	
Total	31	124	230	210	1026	

Table 2

	# Consul- tations	Altered diagnos	Altered treat	Recomms for new studies	Altered diagnos process	Altered interp. of diag results	Intro.of new treat method
Surgical group	44	0/21	12	30	16	2	5
Psychology	25	1/8	17	3	--	--	3
Epid./inf.	15	2/2	4	7	5	2	1
Int. disease	5	0/1	2	2	2	1	-
Diag. visual	33	4/10	--	12	12	15	--
Lab. med.	-				5	4	
Burns	24	--	XX				
Vasc. surgery	16	0/7	1	5	4/?	3	1
Endocrinology	5	1/1	2	2	--	--	2
Ophthalmology	6	1/2	1	--	--	--	1
Neurology	5	1/1	3	2	2	--	1
Urology	25	--	5	7	1	--	2
Dialysis	6	1/1					
Total	210	9/53	47	70	47	27	16

teleconferences were devoted to discussion of methods of treatment since, as a rule, diagnosis was not subject to doubt.

The first surgical conference was held on May 18th. The leading orthopedists and traumatologists of the Republic and directors of the traumatological services in the earthquake zone participated in this conference. The first to speak was the Chief Specialist of the Ministry of Health, Ruben Nicogossian. He described in detail the situation that had developed in the disaster area and in the Republic as a whole and spoke of the procedures for evacuating trauma patients and of the measures taken to provide the most effective aid to the victims at all evacuation stages. Next, physicians from the disaster area spoke. Then 12 patients, the majority of whom had suffered trauma during the earthquake, while two suffered from severe osteomyelitis, and two others from complications following burns, were presented and discussed.

The conference on reconstructive and plastic surgery and transplantation of soft tissue generated a great deal of interest. Physicians from the two major departments devoted to this field in the Republic posed many questions that had arisen during the treatment of the victims, and a major portion of the conferences was devoted to discussion of techniques for various kinds of surgical interventions. The Armenian physicians were given many recommendations with regard to surgical treatment of bed sores and postburn and post-traumatic damage to soft tissue. Consultations were held for six patients.

The conference of May 30th was the most tightly organized. After visual presentation of three spinal patients accompanied by discussion of certain aspects of spinal surgery, the physicians turned to issues of spinal rehabilitation. At this conference, the method of playing video tapes made previously was first used. After a patient with bed sores was shown, questions were put concerning the treatment of bed sores; after a patient with particular ossification was presented, relevant questions about this complication and its treatment were raised.

The recommendations of American specialists on questions of spinal rehabilitation were very useful. The newly established Center of Spinal Rehabilitation in the city of Yerevan, staffed with young specialists without a great deal of experience working with this category of patients, received a great deal of essential information.

The next conference, to be devoted to orthopedics, was interrupted at the very beginning by an urgent unscheduled consultation. A pediatric physician in Salt Lake City, who had been called in specially, held a consultation on a 9-year-old child with severe pulmonary pathology. This consultation could be called one of the most effective -- it resulted in alteration of the diagnosis, and a program of further examination and treatment was recommended. After this child was seen, consultations were held for five orthopedic cases.

The final conference, devoted to neurosurgery, was very substantive. Consultations on individual patients were followed by animated discussions of the efficacy of various diagnostic methodologies and different methods of treating brain injuries.

Many pages of printed information relevant to surgery were received. In addition to the literature requested before or during the conferences, the Americans kindly sent the latest review articles of potential utility to the Armenian physicians. Works on internal fixation of the thoracic portion of the spinal column, classification and treatment of osteomyelitis, retrograde cholangiopancreatography, and many other topics were gratefully received. At the request of the Armenian physicians, articles were sent concerning easing or eliminating causalgic pain in patients suffering from crush syndrome.

These and other materials transmitted by facsimile communications could, and in the opinion of the Soviets, definitely would have a discernible positive influence on the diagnosis and treatment of the relevant categories of patients. The majority of the works obtained were xeroxed and distributed to participants in the conferences. Nonduplicated works were given to coordinators for the appropriate specialties for further dissemination.

Epidemiological and Infectious Diseases

Any of the four conferences held on this topic could be used to demonstrate the expediency and utility of the selection of this subject. The first conference (May 10th, first telebridge conference) was devoted to the epidemiological situation that had developed after the earthquake. The participation of many specialists, including the directors of the Epidemiological Service of the Republic and affected regions and cities, and consideration of the monthly patterns of the incidence of particular diseases

before the disaster, made it possible to find optimal solutions for limiting and eliminating foci of infection if the epidemiological situation were to become more severe. In particular, there was discussion of different scenarios for incidence patterns of acute upper respiratory infection and intestinal infections due to the disruption of water supply and waste disposal systems, food supplies, and prophylactic and therapeutic services in the affected regions. The American colleagues agreed that only those infectious diseases that had been recorded previously or for which the causal agent had been identified in one or another local natural environment were likely to be activated.

Among the pathologies discussed, the most frequently mentioned were bacterial and amebic dysentery, salmonellosis, viral diarrhea, viral hepatitis, toxic infections from food and food poisoning, and meningococcal infections. Also considered were factors such as the death of a large number of [domestic] animals and increase in rodents, including rats. The Armenians described the set of preventive measures that had been taken.

The American physicians were informed of the results of mass operational induction of phagocytic immunity to particular intestinal infections and the use of Interferon to prevent acute upper respiratory infections and judged that these measures were adequate. Certain administrative aspects of epidemiological monitoring of the developing situation were discussed; particularly with regard to cities suffering substantial damage that had had adequate systems of structures for preventing the spread of infection before the catastrophe.

The second conference, devoted to the problem of viral hepatitis, was attended by 18 physicians from Armenia, including 14 from the disaster area, and more than 12 physicians from Bethesda and Utah.

Discussion of the first case lasted 50 minutes. Although the discussion of this very complex case did not resolve the question of concomitant polyarteritis nodosa or persistence of the hepatitis B antigen from the outset as possible reasons for the development of hepatitis, useful advice was given concerning future management of the patient. The soundness of this advice was confirmed by tracking of the antibody titer.

During the discussion, many different approaches to the use of drugs in hepatitis and many different ideas about the efficacy of diagnostic tests came to light. At the end, the American specialists answered questions concerning sensitivity and specificity of particular methods for diagnosing leptospirosis.

The third meeting — on May 17th — was attended by a total of more than 45 specialists. The first half of the conference was spent exchanging experience concerning diagnosis and treatment of viral hepatitis in children. The American physicians provided interesting and useful material on the combination of AIDS and hepatitis B. After a break, the question of treating a child believed to have both hepatitis and yersiniosis was discussed. The consultants argued cogently that the patient did not have a viral infection of the liver and proposed measurement of the hepatitis B antigen as a differential test. The American participants were interested in the extensive use of antioxidants in Armenia. The Armenian specialists sent material concerning their experience and scientific research in this area by facsimile communication.

The fourth conference was devoted to intestinal infections and also to analysis of the most severe complications of infectious pathology, such as toxic shock, hemorrhagic syndrome, and neuritis. The specialists from Bethesda kindly agreed to provide written answers to questions on botulism. The discussion of means for correcting disruption of fluid-electrolyte and acid-base balance in children, including neonates, was very productive.

The Armenian specialists characterized these conferences as "very effective and useful." There is no doubt that these conferences will have a long-term influence on diagnostic and therapeutic tactics for the diseases discussed.

Many pages of printed material on problems of interest to the Armenian specialists were received by facsimile communication. All the material obtained was xeroxed and distributed to the appropriate groups.

Psychology and Psychological Rehabilitation

The conferences on psychology and psychological rehabilitation generated special interest on both sides of the "Armenia-U.S." telebridge. The experienced

professionals working on both ends of the telebridge turned the conferences into absorbing exchanges of opinions, discussion, and debate.

Only the topic of the conference was agreed upon in advance. The psychologists did not consider it essential to send lists of questions or patient data ahead of time. Post-traumatic stress disorders, the effect of the catastrophe on families and children, drug therapy in psychological rehabilitation, group psychotherapy, the use of the mass media, mass examination of people who had been compelled to leave their homes, remote consequences of a major catastrophe with regard to psychological health of the population, effects on individuals already under stress — this is an incomplete list of the problems addressed at these conferences.

Significant emphasis was placed on the psychological effects of the earthquake on medical personnel of the disaster zone, the influence of stress on their work capacity and professional capabilities. Organization of appropriate and complete psychological and psychiatric aid for the population of the disaster zone was considered the most important issue.

It should be noted that before the earthquake, Armenia did not have an adequate independent psychological [aid] service — this service was still in the developmental stage. The small group of psychologists/physicians available were not capable of coping with the severe consequences of the earthquake on the psychiatric health of the population without help from psychiatrists. The Mental Health Center was established after the earthquake. The newly appointed director of the Center, was one of the most active participants in the teleconferences.

Little Conferences

The 10 "little" conferences in 9 medical specialties also were a great success. Of special interest, in the opinion of the Soviet participants, were the conferences on diagnostic visualization, dialysis, vascular surgery, and ophthalmology.

The conference on dialysis coincided with a period of rapid development of this treatment method in Armenia. During the preceding months, a large number of new dialysis centers had been established in the Republic and new specialists in dialysis were trained. The conference gave the physicians the opportunity to receive answers

to many questions that had arisen during the period after the earthquake. Their American colleagues congratulated the Armenian dialysis specialists on their success in treating a large number of cases of crush syndrome associated with the earthquake.

The two conferences on diagnostic visualization permitted discussion of problems of computer tomography, nuclear medicine, x-ray technology, and ultrasound diagnosis. Aside from the many dozen medical images, more than 30 patients whose diagnostic data offered certain interpretation problems were presented for discussion. Before the conferences, the consulting centers had received facsimile material listing questions, to which they provided exhaustive answers during the conference. As a result of the consultations, the interpretations of many diagnostic images were modified. The Armenian specialists received valuable advice concerning improvement of many diagnostic methodologies.

During the conference on vascular surgery, the American physicians provided consultation on 16 patients. This was one of the most animated and interesting conferences held on the telebridge. A technical innovation in this conference was the demonstration of colored slides made during an operation. A sensitive video camera of high quality transmitted the frames projected on the screen of the slide projector.

The conferences on ophthalmology, urology, endocrinology, laboratory diagnostics, and internal diseases were very effective.

CONSULTATION TO UFA

After the Ufa train accident on June 4th, further communications arrangements became necessary in order to link the Ufa Burn Center with the existing Spacebridge. Because of a short lead time and urgency of the situation, it was decided to link Ufa with Yerevan (by land lines) where all transmissions could be patched into the existing Spacebridge and retransmitted to the U.S. This add-on system was capable of two-way voice communications and black-and-white slow scan video. The slow scan video transceivers and camera equipment (at the request of Public Service Satellite Consortium) were generously donated by Colorado Video of Boulder, Colorado. Transportation to and from the U.S.S.R. was provided by Aeroflot.

Transmissions from Ufa began on July 5th and terminated July 12th. Twenty-four patients were presented during this week, with most of them having severe burns. In addition to these cases, there was much discussion concerning general burn treatment, grafting techniques, fluid replacement, and antibiotic prophylaxis. Several hours were also given to psychological problems following burns, particularly those that caused disfigurement of the face.

The Ufa consultations went very well considering the requirement to begin consultations after only a few days' warning. This precluded the use of color video, leaving no alternative other than slow-scan black and white. With slow scan, a still picture of the patient is transmitted every 20-40 seconds. Hence, there was not only no color, but also no movement. Although the American doctors would have preferred full motion color video, given the constraints of the situation, the still-frame photos, strongly supplemented by audio interacting, were considered adequate for its purpose.

RESULTS

Virtually every Soviet and Armenian physician who participated in Spacebridge felt it was highly successful, that it was worthwhile, and that they would participate in a similar such operation again if given the chance.

Spacebridge was an unqualified success, demonstrating that medical care can be effectively delivered through a telecommunication system. It was an example, par excellence, of space age technology helping man to cope with a down-to-earth tragedy.

As a result of this experience, it was concluded that there are four major applications for telemedicine: patient presentations; discussion of general medical topics; diagnostics; and education. For disaster situations, this can be best done if all arrangements were made in advance with participating medical centers and that international agreements addressing communications and funding in particular be negotiated beforehand. With prearranged agreements, a telemedicine system could be installed and operational in the very early phases of a disaster (at 24-28 hours) as well as during the rehabilitation period.

Of utmost importance is good two-way audiovisual capability and a system to permit faxing independently. Although Spacebridge was not capable of televising from the U.S. to Armenia, the LDS Hospital in Salt Lake City was able to arrange televising back to Armenia 2 hours of consultation demonstrating its value. The use of slow scan video received mixed reactions by the U.S. physicians because it was neither in color nor capable of transmitting movement. It would be of value, nevertheless, if regular television was not available. It was also further noted that it transmits diagnostic imaging pictures very well.

The participants agreed that use of broadcasting time is far more efficient if all presentations are scheduled in advance and that the consultations proceed accordingly. This is the only way to ensure that the appropriate specialists are available at the right time for the right patients. Otherwise, the patient will not get the full benefit of specialty consultation. Spacebridge clearly demonstrated that with the proper specialists on hand, as well as complete patient information, including x rays, there will be a direct salutary impact upon diagnosis and treatment. Because of the

success of Spacebridge, the Soviet and U.S. participants unanimously agreed that it should be continued and that efforts should be made to establish an on-call international capability. To this end, a briefing was given on September 11th to a number of Federal agencies involved in disaster response.

General conclusions of the group were as follows:

- a. Spacebridge succeeded at the technical and medical level. It satisfied the objectives to demonstrate on an international level and was adaptable to changing circumstances.
- b. Although medicine and telecommunications have an evolving relationship, specific needs challenge our capacity for compatibility.
- c. International constraints were more substantial than technical or medical considerations to implement the program.
- d. The program led to substantial changes in diagnostic and therapeutic outcome for specific patients, and new technologies in diagnosis and treatment were introduced.
- e. The value of the program extended far beyond the immediate needs of the disaster.
- f. The program accumulated a unique body of information, technical and medical, of international value.
- g. The program established a new and enduring relationship between the medical communities of the U.S.S.R. and U.S.A., involving hundreds of physicians and other health care personnel.
- h. The common ground and sophistication of medicine in Armenia and U.S.A. permitted detailed recommendations about specific patients facilitated by high quality telecommunications.

- i. The practice of medicine via a telecommunications system has direct application to the care of astronauts in space.

An important outgrowth of this program has been the increased awareness of the medical, technical and political institutions of the use of satellite communications for disaster medicine.

Several participants are involved in proposals to continue and expand the Space-bridge concept on a world-wide permanent basis. They are also investigating approaches to reduce its technical, administrative and regulatory complexity and to reduce its cost.

Proposals are also being developed to establish international agreements that would include provisions for facilitating frequency assignments and entry and operations of relief teams and their communications and rescue equipment into foreign countries for disaster relief.

RECOMMENDATIONS

Because Spacebridge to Armenia and Ufa was an unprecedented experiment, much was learned in its planning and execution. During the broadcasts in late June, a few hours were given to lessons learned to make some mid-course corrections. However, in order to have a full, detailed discussion, and to write a final report, representatives from the Soviet Union were invited to Washington, DC, September 8-11, 1989 to meet with their American colleagues. The product of this meeting was this joint Spacebridge report, recommendations, and a Protocol. We hope this experience will serve others should tragedy occur.

1. A Spacebridge telecommunications system should be available for world-wide deployment in event of disaster.
2. International agreements should be negotiated in advance of disasters to address implementation and funding to ensure an unhampered rapid response.
3. National or international organizations should be identified which will take the responsibility for action in the future, to include organization, funding, and implementation.
4. The responsible organization should maintain an updated resource data base to include critical personnel, satellite coverage, etc.
5. Prior to the inception of such a project there must be an analysis of cultural and medical practices to establish a common language for lab instruments and data, medical technology, pharmaceuticals, surgical instruments, etc. Pharmacopeias should be exchanged.
6. A subgroup (mainly spacebridge to Armenia and Ufa participants) should be formed for the purpose of
 - a. finding a national or international organization to continue spacebridge
 - b. transferring its telemedicine expertise and knowledge to other appropriate agencies.

- c. completing the analysis of data, organizing international workshops, and preparing joint publications in Russian and English.
- 7. A permanent subgroup under the auspices of the Soviet-U.S. Space Biology and Medicine Joint Working Group should also be formed for the purpose of
 - a. standardizing telemedicine procedures in space.
 - b. providing experts to deal with emergency needs in space flight.
 - c. supporting research to advance telemedicine support for space flight and facilitating development and evaluation of space medicine to provide optimum medical care to man in space.
 - d. advising as to how space telemedicine advances can best be applied to terrestrial medical needs.
- 8. Medical centers with comprehensive specialty services should be preselected for Spacebridge operations and its staff trained for telemedicine operations. Specialty consultation should be available for pediatric and burn cases. All participating medical centers must be committed and ready to respond on short notice.
- 9. There should be a two way video so patients and consultants can see one another. Also should consider telecommunications to demonstrate techniques in the operation room.
- 10. There should be capability to fax simultaneous with audiovisual transmissions.
- 11. Patient presentations and discussions should adhere strictly to prearranged schedules to ensure that the proper specialists are available. With undependable scheduling, specialists may be absent which will result in a deficient consultation.
- 12. Conferences can be of 1-4 hours duration with scheduled breaks.

13. A common consistent format for patient presentation as well as for fax'd material is essential.
14. FAX material must be sent ahead of time to ensure proper presentation and availability of the appropriate consultants at the right time.
15. A proper facility for patient presentation including physical examination is essential.
16. Use keyed microphones to avoid echos.
17. Consider use of digitized video for 2-way capability.
18. Translation, written and oral, should be given high priority. (Simultaneous translation would be advantageous.)
19. Critical communication elements include FAX, audio, and video. Optimal would include two-way color video with color slow-scan video availability.
20. Use slow scan as an alternative to regular video.
21. Begin any Spacebridge project with overall description of the disaster and video if possible of the disaster area to be viewed by participating consultants.
22. Must know cases in advance, presented on time with right specialists in the room at the right time.
23. Advantageous to have skilled presenters who can do a good physical examination on TV.
24. Telemedicine should be part of medical school curricular as it will probably be a part of private practice in the future. Techniques need to be developed to make it as effective as possible.
25. Should have pointer capability for imaging and patient examination.

26. All x rays of patients to be presented should be on hand.
27. Develop through sustaining and educational programs, international teams which could respond promptly to implement the programs.
28. The data from the program should be analyzed in a scholarly way to permit joint publication coordinated by Drs. Arnauld Nicogossian and Haik Nikogossian.

SUPPORTING MATERIALS

- A. Initial Protocol
- B. Implementation Plan
- C. Calendar Schedule
- D. Weekly Status Reports
- E. Final Protocol



Appendix B

THE REVITALIZATION OF HEALTH AND EDUCATION IN RURAL AMERICA ACT OF 1992

General:

During the preceding decade of the 1980's, rural communities witnessed an exodus of over 5 million residents to urban and suburban areas of the nation. It has become increasingly clear that rural parts of the country must adopt aggressive strategies to strengthen rural communities and enhance the quality of life for its citizens into the 21st century.

Studies by the U.S. Department of Commerce, Office of Technology Assessment, and the Aspen Institute all identify advanced telecommunications systems as the linchpin for a vigorous future for rural America. The Revitalization of Health and Education in Rural America Act of 1992 incorporates these recommendations into viable strategies to improve health care and educational services for rural citizens. By linking up hospitals and schools through advanced telecommunications technology, vast geographic distances are instantly reduced. With the proper infrastructure in place, up-to-date telecommunications services will facilitate endless opportunities for improving the quality of life in remote areas. This comprehensive legislation is the critical first step in forging a partnership with urban communities to create an economically sound and technologically advanced America for generations to come.

Improvement of Health Care and Educational Services in Rural Areas through the Implementation of Interactive Telecommunications Systems.

The bill sets up a program through the Rural Electrification Administration (REA) for providing grants to qualified health and education

consortia to assist them in obtaining access to modern interactive telecommunications systems through the public switched network. A qualified health care consortium is made up of a large health facility linked up with at least three rural hospitals, clinics, community health centers, migrant health centers or local health departments. A qualified education consortium is a consortium of not less than three educational institutions accredited by the State.

In order for a State's potential grantees to participate in the program, the Governor of that State must submit a plan to the Administrator of REA to upgrade and modernize its rural telecommunications infrastructure and improve the use of telecommunications, computer networks, and related advanced technologies within ten years. An interested health or education consortium would then submit a plan to REA to provide more comprehensive health or education services through interactive telecommunications systems in order to receive a grant. The bill sets out de minimis standards for the Governor to meet in order for the State to have eligible grant applicants.

In selecting the grantees, the Administrator of REA must prioritize those grants which have the greatest likelihood of success, participation of the local telecommunications exchange carrier, and support of the local community. The grants are capped at \$1.5 million per consortium and must be used for the purpose of improving health care and education as provided under the bill through a qualified health or education consortium. As an incentive for local telephone exchange carriers to upgrade existing facilities, a telephone borrower can receive a low interest loan through REA if the State in which the borrower does business has a qualified plan submitted by the Governor of that State to REA.

Grants to improve health care in rural areas can be used for consultations between health care providers; transmitting and analyzing x-rays, lab slides and other images; and providing continuing education programs for physicians. Grants to improve education in rural areas can be used for the development of innovative education programs and expanding curriculum offerings; providing continuing education to all members of the community; providing the means for libraries of educational institutions and public libraries to share resources; provide public access to State and national data bases; and conducting town meetings for educational purposes.

The bill authorizes \$30 million to be appropriated for health care consortia and \$20 million to be appropriated for education consortia. The legislation amends the Rural Electrification Act in order to provide Section 305(b) insured 4% loans to telephone companies that participate in the Governor's plan. The Act is further amended to provide for the rural population requirement under the

telephone loan program of REA to be increased from 1,500 to 10,000 in order to enhance participation by those local telephone exchange carriers not currently upgrading in their service areas. There is a "Sense of the Congress" provision stating that those local telephone exchange carriers interested in upgrading their service territory with REA loans, but are reluctant due to the lien requirements, may set up a subsidiary for that exchange in order to borrow from REA.

102D CONGRESS
2D SESSION

H. R. 5238

IN THE HOUSE OF REPRESENTATIVES

Mr. ENGLISH introduced the following bill; which was referred to the
Committee on _____

A BILL

To establish a grant program to improve the provision of health care services and educational services in rural areas by enabling providers of such services to obtain access to modern interactive telecommunications systems, and for other purposes.

1 *Be it enacted by the Senate and House of Representa-*
2 *tives of the United States of America in Congress assembled,*

3 **SECTION 1. SHORT TITLE.**

4 This Act may be cited as the "Revitalization of
5 Health and Education in Rural America Act of 1992".

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1 SEC. 2. GRANTS TO ENABLE PROVIDERS OF HEALTH CARE
2 AND EDUCATIONAL SERVICES IN RURAL
3 AREAS TO IMPLEMENT INTERACTIVE TELE-
4 COMMUNICATIONS SYSTEMS.

5 (a) FINDINGS.—The Congress finds that—

- 6 (1) interactive telecommunications systems hold
7 the potential to alleviate many of the problems rural
8 Americans face in obtaining access to adequate
9 health care and expanded educational services; and
10 (2) access to such systems by providers of
11 health care services and educational institutions in
12 rural areas would greatly increase their ability to
13 provide more comprehensive health care and edu-
14 cation to rural, underserved populations.

15 (b) GRANT PROGRAM.—Subtitle D of title XXIII of
16 the Food, Agriculture, Conservation, and Trade Act of
17 1990 is amended by adding at the end the following:

18 "CHAPTER 3—IMPROVEMENT OF HEALTH CARE
19 SERVICES AND EDUCATIONAL SERVICES
20 THROUGH TELECOMMUNICATIONS

21 "SEC. 2338. GRANT PROGRAM

22 "(a) ESTABLISHMENT.—The Administrator of the
23 Rural Electrification Administration (in this chapter re-
24 ferred to as the 'Administrator') shall establish a program
25 for providing grants to any qualified consortium to assist
26 the consortium in obtaining access to modern interactive

1 telecommunications systems through the public switched
2 network.

3 “(b) DEFINITIONS.—

4 “(1) QUALIFIED CONSORTIUM.—As used in this
5 chapter, the term ‘qualified consortium means a
6 consortium which—

7 “(A) provides health care services or edu-
8 cational services in a rural area of a qualified
9 State; and

10 “(B) is composed of—

11 “(i) a tertiary care facility, rural re-
12 ferral center, or medical teaching institu-
13 tion, or an educational institution accred-
14 ited by the State;

15 “(ii) any number of institutions that
16 provide health care services or educational
17 services; and

18 “(iii)(I) in the case of a consortium
19 seeking a grant under this chapter to im-
20 prove health care services, not less than 3
21 rural hospitals, clinics, community health
22 centers, migrant health centers, local
23 health departments, or similar facilities; or

24 “(II) in the case of a consortium seek-
25 ing a grant under this chapter to improve

1 educational services, not less than 3 edu-
2 cational institutions accredited by the
3 State.

4 “(2) QUALIFIED STATE.—The term ‘qualified
5 State’ means a State which has adopted, within 1
6 year after the date final regulations are prescribed
7 to carry out this chapter, a plan for the upgrading
8 and modernization of the rural telecommunications
9 infrastructure of the State which, among other
10 things—

11 “(A) provides for the elimination of party
12 line service in rural areas of the State;

13 “(B) encourages and improves the use of
14 telecommunications, computer networks, and
15 related advanced technologies to provide edu-
16 cational and medical benefits to people in rural
17 areas of the State;

18 “(C) provides for an enhancement in the
19 quality and availability of educational opportu-
20 nities for students in rural areas of the State;

21 “(D) provides for improvement in the qual-
22 ity of medical care provided, and access to med-
23 ical care afforded, to people in rural areas of
24 the State;

1 “(E) provides incentives for local telephone
2 exchange carriers to improve the quality of tele-
3 phone service and access to advanced tele-
4 communications services for subscribers in rural
5 areas of the State, including facsimile document
6 transmission, multifrequency tone signaling
7 services, interactive audio and video trans-
8 missions, voicemail services, and other tele-
9 communications services;

10 “(F) provides for the full participation of
11 rural areas in the modernization of the tele-
12 communications network through the implemen-
13 tation of joint coordinated network planning,
14 design, and cooperative implementation among
15 all local telephone exchange carriers in the pro-
16 vision of public switched network infrastructure
17 and services;

18 “(G) provides for the achievement, preser-
19 vation, and enhancement of universal service by
20 bringing reasonably priced, high-quality, ad-
21 vanced telecommunications network capabilities
22 to the people of the rural areas of the State, in-
23 cluding through the sharing of public switched
24 network infrastructure and functionality by
25 local telephone exchange carriers at the request

1 of local telephone exchange carriers lacking
2 economies of scale or scope to provide such in-
3 frastructure or functionality on their own;

4 “(H) provides for the achievement of such
5 goals within 10 years after the adoption of the
6 plan; and

7 “(I) does not alter the boundaries of any
8 local telephone exchange company franchised
9 service area designated or recognized by the
10 State, or the equivalent in the State.

11 “(3) RURAL AREA.—The term ‘rural area’ has
12 the meaning given such term in section 203(b) of
13 the Rural Electrification Act of 1936.

14 “(4) TELEPHONE SERVICE.—The term ‘tele-
15 phone service’ has the meaning given such term in
16 section 203(a) of the Rural Electrification Act of
17 1936.

18 “(c) SELECTION OF GRANT RECIPIENTS.—

19 “(1) APPLICATION REQUIREMENT.—

20 “(A) IN GENERAL.—Any qualified consor-
21 tium that provides services in a State and de-
22 sires to obtain a grant under this chapter shall
23 submit to a State agency designated by the
24 Governor of the State an application in such
25 form, containing such information and assur-

1 ance, and at such time, as the Administrator
2 may require.

3 “(B) CONTENTS OF APPLICATION.—The
4 application shall contain or be accompanied
5 by—

6 “(i) a copy of the State plan described
7 in subsection (b)(2);

8 “(ii) the plan of the applicant, for ob-
9 taining access to interactive telecommuni-
10 cations systems, which—

11 “(I) specifies, consistent with
12 subsection (f), the uses to be made of
13 such systems;

14 “(II) demonstrates that the sys-
15 tems will be capable of being readily
16 connected to the established public
17 switched network; and

18 “(III) is compatible with the
19 State plan; and

20 “(iii) a commitment by the State to
21 make a grant to the applicant in an
22 amount equal to 20 percent of the funds
23 required to carry out the plan of the appli-
24 cant, conditional upon a commitment by
25 the Administrator to make 1 or more

1 grants to the applicant under this chapter
2 in an amount equal to 80 percent of the
3 funds required to carry out the plan of the
4 applicant.

5 “(2) REVIEW AND COMMENT.—The State agen-
6 cy shall review the application and the applicant’s
7 plan and, after any revisions made by the applicant
8 are incorporated, transmit to the Administrator the
9 application and plans, and the comments of the
10 State agency.

11 “(3) SELECTION OF GRANTEES.—The Adminis-
12 trator shall—

13 “(A) review the applications and plans
14 transmitted pursuant to paragraph (2);

15 “(B) consider the comments of the State
16 agency with respect to the application; and

17 “(C) make grants in accordance with para-
18 graph (4) to each applicant therefor that com-
19 plies with the requirements of this chapter and
20 the regulations prescribed by the Administrator
21 to carry out this chapter.

22 “(4) PRIORITIES.—Priority for grants under
23 this chapter shall—

24 “(A) be accorded to applicants whose ap-
25 plications demonstrate—

1 “(i) the greatest likelihood of success-
2 fully and efficiently carrying out the activi-
3 ties described in subsection (f)(1);

4 “(ii) the participation of the local tele-
5 phone exchange carrier in providing and
6 operating the telecommunications trans-
7 mission facilities required by the plan; and

8 “(iii) unconditional financial support
9 from the local community; and

10 “(B) so as to ensure, to the extent pos-
11 sible, that various regions of the United States
12 benefit from the use of the grants.

13 “(d) MAXIMUM AMOUNT OF GRANT.—The amount of
14 each grant under this chapter shall not exceed \$1,500,000.

15 “(e) DISTRIBUTION OF GRANTS.—Grants to any
16 qualified consortium under this chapter shall be disbursed
17 over a period of not more than 3 years.

18 “(f) USE OF FUNDS.—

19 “(1) IN GENERAL.—Grants under this chapter
20 may be used to support the costs of activities involv-
21 ing the sending and receiving of information to im-
22 prove health care services or educational services in
23 rural areas, including—

24 “(A) in the case of grants to improve
25 health care services—

1 “(i) consultations between health care
2 providers;

3 “(ii) transmitting and analyzing x-
4 rays, lab slides, and other images;

5 “(iii) developing and evaluating auto-
6 mated claims processing, and transmitting
7 automated patient records; and

8 “(iv) developing innovative health pro-
9 fessions education programs;

10 “(B) in the case of grants to improve edu-
11 cational services—

12 “(i) developing innovative education
13 programs and expanding curriculum offer-
14 ings;

15 “(ii) providing continuing education to
16 all members of the community;

17 “(iii) providing the means for libraries
18 of educational institutions or public librar-
19 ies to share resources;

20 “(iv) providing the public with access
21 to State and national data bases;

22 “(v) conducting town meetings; and

23 “(vi) covering meetings of agencies of
24 State government; and

25 “(C) in all cases—

1 “(i) transmitting financial informa-
2 tion; and

3 “(ii) such other related activities as
4 the Administrator deems to be consistent
5 with the purposes of this chapter.

6 “(2) LIMITATION ON ACQUISITION OF INTER-
7 ACTIVE TELECOMMUNICATIONS EQUIPMENT.—Not
8 more than 40 percent of the amount of any grant
9 made under this chapter may be used to acquire
10 interactive telecommunications end user equipment.

11 “(3) LIMITATION ON USE OF CONSULTANTS.—
12 Not more than 5 percent of the amount of any grant
13 made under this chapter may be used to employ or
14 contract with any consultant or similar person.

15 “(4) PROHIBITIONS.—Grants made under this
16 chapter may not be used, in whole or in part, to es-
17 tablish or operate a telecommunications network or
18 to provide any telecommunications service for hire.

19 “(g) LIMITATIONS ON AUTHORIZATION OF APPRO-
20 PRIATIONS.—

21 “(1) GRANTS TO IMPROVE RURAL HEALTH
22 CARE SERVICES.—For grants under this chapter to
23 improve health care services, there are authorized to
24 be appropriated to the Administrator not to exceed
25 \$30,000,000.

1 “(2) GRANTS TO IMPROVE RURAL EDU-
2 CATIONAL SERVICES.—For grants under this chap-
3 ter to improve educational services, there are author-
4 ized to be appropriated to the Administrator not to
5 exceed \$20,000,000.

6 “(3) AVAILABILITY OF FUNDS.—Sums appro-
7 priated pursuant to this subsection are authorized to
8 remain available until expended.”.

9 (c) REDUCTION IN INTEREST RATE ON INSURED
10 TELEPHONE LOANS FOR BORROWERS FROM STATES
11 WITH PLANS FOR UPGRADING RURAL TELECOMMUNI-
12 CATIONS INFRASTRUCTURE.—Section 305(b) of the Rural
13 Electrification Act of 1936 (7 U.S.C. 935(b)) is amended
14 by adding after and below the end the following:
15 “Notwithstanding the preceding sentence, an insured tele-
16 phone loan made under this section on or after the date
17 of the enactment of this sentence to an otherwise eligible
18 borrower therefor in any qualified State (as defined in sec-
19 tion 2338(b)(2) of the Food, Agriculture, Conservation,
20 and Trade Act of 1990), which would (but for this sen-
21 tence) bear interest at more than 4 percent per annum,
22 shall bear interest at 4 percent per annum.”.

23 (d) ELIMINATION OF PREFERENCE FOR RURAL
24 TELEPHONE BANK LOANS FOR BORROWERS LOCATED IN
25 STATES WITH PLANS FOR UPGRADING RURAL TELE-

1 COMMUNICATIONS INFRASTRUCTURE.—Section 408(b)(2)
2 of the Rural Electrification Act of 1936 (7 U.S.C.
3 948(b)(2)) is amended by inserting “which is not located
4 in a qualified State (as defined in section 2338(b)(2) of
5 the Food, Agriculture, Conservation, and Trade Act of
6 1990)” after “any borrower”.

7 **SEC. 3. INCREASE IN LIMITATION ON POPULATION OF**
8 **RURAL AREAS FOR PURPOSES OF TELE-**
9 **PHONE LOANS.**

10 (a) IN GENERAL.—Section 203(b) of the Rural Elec-
11 trification Act of 1936 (7 U.S.C. 924(b)) is amended by
12 striking “one thousand five hundred” and inserting
13 “10,000”.

14 (b) CONFORMING AMENDMENT.—Section 13 of such
15 Act (7 U.S.C. 913) is amended by inserting “(except in
16 title II)” before “shall be deemed to mean any area”.

17 **SEC. 4. SENSE OF THE CONGRESS.**

18 It is the sense of the Congress that persons who are
19 eligible for telephone loans under the Rural Electrification
20 Act of 1936 and are interested in upgrading telecommuni-
21 cations in rural areas should obtain financial assistance
22 under such Act through a subsidiary in order to limit the
23 assets subject to the lien requirements of such Act.

1 **SEC. 5. REGULATIONS.**

2 Within 180 days after the date of the enactment of
3 this Act, the Administrator of the Rural Electrification
4 Administration and the Governor of the Rural Telephone
5 Bank shall prescribe such regulations as may be necessary
6 to carry out the amendments made by this Act.

Appendix C

ATTENDEE MAILING LIST
International Telemedicine/Disaster Medicine Conference
9 - 11 December 1991
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Bethesda, Maryland USA

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9 - 11 December 1991
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International Telemedicine/Disaster Medicine Conference
9 - 11 December 1991
Uniformed Services University of the Health Sciences
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9 - 11 December 1991
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